The Dock and Harbour Authority

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Editorial Comments

Tokyo—A Great City and Port of the Orient.

For our leading article this month we have drawn upon the resources of a region, generally and somewhat vaguely described as "The Far East," the very distance and remoteness of which confers upon it the potent attraction of strange and unfamiliar things. Japan, "Land of the Rising Sun," symbolised on its banners by a flaming disc with radiating rays, is to the European, and particularly to the British, mind, a country of mystery and obscurity, arising, no doubt, in part from the inscrutable, impassive countenances of its almond-eyed inhabitants. For ages, the country was steeped in a haze of tradition and feudalism, practising (as it does still) an occult religion, based on ancestral worship, profoundly alien to Western habits of thought. Only quite recently in a relative sense, and in the same sense quite suddenly (having regard, that is, to the gradual progress of civilisation elsewhere) has there been adopted a system of Western culture, which being imposed on a fundamental layer of native custom, is not without some incongruity.

The modernisation of Japan dates from the closing years of last century. After a long epoch of monarchical despotism, the people were granted a constitution, more or less on democratic lines, in 1890, and thereafter, the country commenced to be associated with the general progress and development of the nations of the world. So much had been achieved during the ensuing decade that Great Britain entered into alliance with her in 1902, and nine years later another treaty was negotiated which made Japan an ally of this country in the war of 1914-18.

Latterly, however, as is well known, there has been a revolutionary change of attitude. Japan, no longer an ally, is not even a friendly country, judging from the truculent and menacing policy of her rulers. She has ceased to believe in democracy and, obsessed by ideas of domination in Asia on the lines of the European totalitarian governments, is following the lead of Hitler and Mussolini wherever it may take her.

Though not in itself a great port, since it derives the major part of its maritime importance from the auxiliary and adjacent port of Yokohama, Tokyo possesses a special significance in its role of national capital. Located at the head of the bay of the same name, and on the banks of the River Sumida, which, though of ample width, is too shallow for the requirements of sea-going vessels, it has hitherto been hampered in its development by physical defects. For this reason, its overseas trade has hitherto been carried on through Yokohama which is 18 miles distant by rail.

Formerly, the city was called Yedo, meaning Estuary Gate, whereas its present name signifies Eastern Capital. Although of ancient origin, it has few notable historical records. There is no mention of Yedo in Japanese annals before the end of the 12th Century, and it only began to gain notice about the year 1457, when Ota Dokwan built a castle at the site. The real importance of the place dates from the end of the 16th Century.

Tokyo is now a city of nearly seven million inhabitants, ranking next after London and New York in point of population. So vast an aggregation of people, with their needs and occupations, demands a great movement of trade, and by reason of the insularity of the country, this trade is, perforce, predominantly maritime. Considerable importance, therefore, attaches to the progress which the city is making in commerce and world affairs, so that the article which will be found elsewhere in this issue, descriptive of recent port developments in the Japanese capital will be read with interest, especially by those concerned with trade with the "Far East."

By the latest mail to hand comes the announcement of the approval by the Harbour Commission of the Japanese Home Ministry of a scheme for the more intimate physical connection of the harbours of Tokyo and Yokohama by the construction of two canals and by the enlargement of shipping accommodation at the former port. It is further intended to reclaim an extensive tract of submerged land along the Tokyo waterfront to provide for an Industrial Zone.

Port Development from a Mechanical Standpoint.

In his Presidential Address to the Institution of Mechanical Engineers in the latter part of October, Mr. Asa Binns mentioned the interesting fact that he had found on looking through the list of Past Presidents during a period covering nearly a century, that he was the first occupant of the chair whose professional career had been largely devoted to Dock Engineering. The informative account of the development of the Port of London which followed, not only showed the important part, first as a Resident and then as Chief Engineer, which Mr. Binns had taken in the furtherance of London dock expansion, but also demonstrated, *ipso facto*, the wide field of activity in port work open to mechanical engineers.

For the historical review of the port, which formed the main theme of the address, we must refer our readers to the report contained in subsequent pages of this issue. There is much of interest in the survey, but two topics stand out with special prominence and to these some allusion may appropriately be made.

The first has already been discussed in these Editorial Comments, a little over three years ago. It related to the project for a barrage across the Thames, which, if it had been carried out, would have fundamentally altered the structure and operation of the port. The scheme was promoted by certain individuals who formed themselves into an Association for the purpose in the early part of 1935. Notwithstanding the vigorous propaganda and enthusiasm of the proponents, it was criticised and condemned by the responsible authorities, even prior to the public enquiry which was arranged to be held in the Spring of 1938. It will be remembered that the project was abandoned on the eve of the inquiry, by reason of the veto of the Committee for Imperial Defence, who considered it dangerous, on account of the vulnerability to aerial attack of the proposed dam. There were other objections equally vital, and Mr. Binns recapitulated the most important of them, such as the inadequacy of the lockage facilities from a shipping point of view, the detrimental interference with the tidal regimen of the river, the probable harmful effect on public health and the excessive cost of construction and maintenance.

The second topic of special interest was refrigeration and the cold storage of perishable foodstuffs, such as meat, fish, dairy produce, etc., which are leading features of the warehousing business of the Port of London Authority. It is only sixty years since the first cold store was opened at the Royal Victoria Dock. We recall reading some of the difficulties attending the transport of refrigerated produce in those early days, and how

Editorial Comments—continued

cargoes from abroad arrived at first in anything but a fit state for human consumption. Mr. Binns mentioned the great progress that has been made in the industry and the developments in treatment which have done so much to ensure a regular supply of food in sound condition.

These and other matters of technical interest combine to make the address one of special importance to port officials and particularly to dock engineers.

Ancient Harbours.

While Mr. Binns in his Presidential Address dealt more particularly with the story of a great port within modern times, the President (Sir Leopold Savile) of the senior body—the Institution of Civil Engineers—devoted his attention, when taking the Presidential chair early in November, to the subject of ancient harbours, " from the dawn of written history to the early days of the Roman Empire." We propose in a succeeding issue to reproduce this interesting survey of the achievements of harbour engineers of bygone generations, the remains of whose works bear witness to a high degree of engineering skill and technical ability. Meanwhile, there is the interesting coincidence that the presidential chairs of the two leading technical institutions are occupied at the present time by distinguished engineers whose main activities have been associated with dock and harbour construction.

Grain Dust Explosions.

Dust explosions and fires in granaries and silos are happily not very common occurrences in Great Britain: certainly they do not appear to be so notable, or so frequent, as those experienced in America, judging from the instances quoted by Dr. David Price in his article on the subject which appears in the present issue. There may have been minor accidents of the kind unattended by consequences of sufficient importance to be recorded in the public press, but the catastrophe incidents at Chicago and Houston in 1939, at St. Joseph, Mo., and elsewhere in North America in the current year, have scarcely been paralleled on this side of the Atlantic. It may be that British methods of dust separation and collection are more efficient though this is difficult to affirm in view of the care which is taken to provide ample cyclones and fans in American installations.

In any case, the risk of explosion in a dust-laden atmosphere is incontrovertible and we are convinced that the observations and recommendations of a chemical expert of the standing of Dr. Price will command the attentive consideration of those of our readers who are responsible for the safe housing of grain cargoes at the ports of this country.

When in Philadelphia some fourteen years ago we had an opportunity of inspecting a recently completed grain elevator of modern type erected by the Reading Railroad Company. It has a storage capacity of 2,500,000 bushels and is equipped with the most up-to-date and efficient plant. Discussing the subject of dust explosions with members of the technical staff, we were informed that, in their opinion, the process, though rapid, is cumulative, commencing with a comparatively slight outburst, which does little damage itself but produces sufficient pressure intensity to dislodge dust lying in ledges and in crevices, thereby creating a denser cloud of dust which results in a succession of explosions of increasing violence. The remedy they advocated was the immediate relief of pressure. Accordingly, the windows of the elevator building have been fitted with a device which ensures that they will open at the slightest pressure from the interior, and will remain open until manually closed. For the same reason, the walling is made up of panels capable of yielding readily to local pressure.

These may be helpful expedients, but they do not remove the root cause of the trouble, which lies in the excessive accumulation of dust particles in a confined space. Efficient ventilation, combined with the mechanical extraction of dust from the grain would appear to be the essential precaution.

The Danube Commission.

The announcement in the foreign press that the Danube Commission has been re-constituted with the inclusion of Russia as a constituent member, is of interest in navigational no less than in political circles, for the Danube is a great European commercial waterway of international importance. Great Britain, indeed, has found it necessary to lodge a protest against the exclusion of her representation and to notify Russia that the step is a " violation of existing treaties." The Soviet Government has retorted that in view of the recent acquisition of Bessarabia from Roumania, there are definite riparian rights to which Russia is entitled and that, in point of fact, " the formation of the Danube Commission, with the participation of the U.S.S.R. and other states situated on or near the Danube, constitutes the restoration of justice violated by the Versailles and other Treaties, on the strength of which, the British Government, having played a leading part in this matter, the U.S.S.R. was kept out of the International as well as the European Danube Commission."

There is a good deal in the tone and substance of this rejoinder which is reminiscent of Nazi language and propaganda. At the same time, it must be admitted that, apart from the legal aspect of the affair, the fact that the Russian border now runs along a considerable part of the northern bank of the river affords some justification for the Soviet attitude. Mr. Butler, the Under-Secretary at the Foreign Office, has explained in Parliament that the protest, while making it clear that the desire of the Soviet Union to take an interest in the territories bordering on the Danube is appreciated, was more specifically directed to the action of the Union in agreeing to become a party to an arrangement which included Italy, but excluded Great Britain from participation.

The International Danube Commission is not to be confused with the European Commission of the Danube, though, possibly, the two bodies have been amalgamated under the new scheme. As readers of this Journal are aware, the latter body has been concerned with the improvement of the navigable waterway for the traffic in grain and other commodities which passes from Central Europe. It was charged (as explained in an article in our issue of September, 1938), with the execution of such works as might be desirable for freeing the river mouths from the accumulation of silt and debritus which interfered with the passage of vessels. It had four technical members, of English, French, Italian and Roumanian nationality respectively.

The International Commission, so far as can be gathered, is a political organisation which exercises jurisdiction and administrative control over the main stream above the mouths.

The Harbour of Taranto.

Scarcely a month passes without the war news bringing into prominence some European or African port or harbour which, while it would be manifestly unjust to describe as hitherto obscure has, none the less, been undistinguished among the general run of maritime trading centres. Since the outstanding achievement of the British Naval Air Arm on November 11th, the name of Taranto has resounded throughout the world and become a topic of universal discussion. Curiously enough, the port, which is of ancient origin and in Roman times known as Tarentum, was primarily a Greek, or, more precisely, a Spartan, colony, founded towards the close of the 8th century B.C. It naturally attracted sea-going adventurers, for it possesses an admirable natural land-locked harbour, formed by a low, rocky peninsula. In modern times, it has been utilised as a naval establishment and dockyard for the Italian navy, which has shown a decided preference for the safe anchorage provided in the Mare Grande and the Mare Piccolo, as the commodious inner basins are called, to the dangers and risks of the outer seas.

The governing depth of water at the entrance and alongside the quays is given as 26½-ft. The ship-repairing facilities include a graving dock, 656-ft. long by 100-ft. width at entrance. This, and whatever other accommodation their may be, is likely, in consequence of recent British naval operations, to be kept occupied for some time.

Road Transport at British Ports.

Among the subjects which have been under discussion by the Road Haulage Consultative Committee appointed by the Minister of Transport towards the end of August last, is the question of road transport to and from the quayside at British ports. Such matters as the pooling of vehicles, the adjustment of speed restrictions on commercial vehicles and the promotion of road safety have been given detailed attention. Methods of operating road transport pools will necessarily differ at various ports according to the local conditions, but, as a result of their examination of the problem, the Committee expect to be able to formulate certain general principles which will facilitate smooth working. Among several proposals considered was that of increasing the " unladen weight " limit of the motor car class of commercial vehicles. This would have the effect of permitting a higher rate of speed for a large number of goods vehicles.

Port Sanitation and Imported Epidemics.

Considerable responsibility rests upon Port Medical Officers and Sanitary Inspectors in the normal routine of port affairs, but in times of international convulsion and upheaval, the burden is materially increased. The influx of refugees, the ruin and devastation wrought by air raids and the congestion of convoy arrivals, all need special precautions in port areas to prevent the spread of epidemics. The virulence of the wave of influenza which swept over Great Britain after the war of 1914-18, is an object lesson in the terrible consequences of any laxity in vigilance, and port medical services are already being warned to deal with the possibility of similar visitations, which it is to be hoped will be frustrated in time.

The Port of Tokyo

An Account of Recent and Impending Developments

By S. KITAMURA, Harbour Bureau, City of Tokyo.

Historic Review

THE recent remarkable development of Tokyo Harbour is in strange contrast to its neglect in days gone by, despite its importance as a capital city. Its present prosperous condition is due to the foresight of many persons who fought for its improvement. Some 86 years ago, as the result of Commodore Perry's expedition to Japan, Yokohama, as well as Hakodate and Nagasaki opened their harbours as treaty ports. Since then, the great Emperor Meiji removed the capital of Japan from Kyoto to Tokyo and henceforward the population of this city has rapidly increased.

Fig. 1. Anchorage at Buoys.

In 1884, Mr. Akimasa Yoshikawa, then Governor of the Tokyo Prefecture, presented his report on "Constructional work in Shinagawa Bay" to the late Prince Saneyoshi Sanjo, through the late Prince Aritomo Yamagata. Thereupon, such prominent persons as General Kabayama, Messrs. Yajiro Shinagawa, Eiichi Shibusawa and Takashi Masuda studied the possibility of the plan, but, as it required about 20,000,000 yen for harbour construction, the plan was shelved. However, in 1896, Mr. Toru Hoshi, an enthusiastic advocate for the harbour construction, was elected as the chairman of Tokyo Municipal Assembly. In 1899, he himself occupied the position as the chief of the committee of the harbour construction investigation and devoted his personal attention to the improvement of the Tokyo Harbour. Accordingly, Mr. Masahisa Matsuda, then Mayor of Tokyo, made an application to the Home Ministry for permission to commence the construction of Tokyo Harbour, and at the same time requested a subsidy from the government; a Bill to this effect was presented to the Diet. The Bill passed the Diet and construction was about to be started when Mr. Hoshi was suddenly assassinated, and the project again was brought to a standstill.

In 1903, Dr. Rentaro Naoki, an engineer of Tokyo Municipality, presented a report to the Mayor. At the same time he put forward a scheme for the improvement of the Sumida River, which might serve to initiate future Tokyo Harbour development. However, the question of the Tokyo Harbour construction was neglected for some time. The work executed during a period of ten years consisted only of small scale improvements in the navigational reach of the River Sumida.

Harbour Limits

The Tokyo Harbour is very extensive; the area is bounded by the mouth of the River Tama in the South and the mouth of the River Edo in the East. The portion generally known, however, as Tokyo Harbour contains some 9,250,000 sq. metres, being approximately the same area as that of Nihonbashi and Kyogashi, of Tokyo City.

Improvement of Entrance Channel

With the completion of the first and second Sumida River improvements at a cost of close upon 4½ million yen attention was once more directed to port development. Steps were taken to dredge a ship channel and an anchorage area, the latter being situated at a point inside the six "Daiba" or feudal fortified islets in Tokio Bay. The channel was 3.6 metres deep and from 127 to 218 metres wide and the dredged material enabled the reclamation of 1,260,000 sq. metres of land to be effected.

Prior to 1923, only ships of light draught could enter the harbour. Craft of 2,000 tons were beyond its capacity and although they brought large volumes of supplies to Tokyo, many of them grounded at low water. The step of improving the accommodation was recognised as imperative and following the completion of the third Sumida River improvement scheme, the port was in a position to receive an annual volume of 3,600,000 tons of cargo.

In September, 1923, the great earthquake occurred in the Kanto district and all overland traffic was suspended. Consequently, the port was overcrowded with many vessels carrying relief materials and much inconvenience was caused by the inadequacy of the landing facilities. Immediately after the earthquake, the city hurriedly constructed piers and warehouses as a temporary measure and the present piers were commissioned in 1926.

The present project is on a large scale with an estimated cost of 36,000,000 yen, extending over 13 years, and was started in 1931.

Present Condition of the Maritime Installations.

The navigation route is located between the second and fifth "Daibas" or forts constructed for defence purposes during the period of the Tokugawa Shogun, and extends about four miles in length to the South-East with a width of 145 metres and a depth of 6.7 metres at low tide, providing safe navigation for all vessels. Lighted buoys are placed at both sides of the entrance of the passage. (Fig. 1).

For the safe mooring of vessels, piers and quays were constructed at the first, second and third Chome (block) Kaigandori (beach), their entire length being 1,783 metres.

The depth of the water within the port is between 6.7 metres and 7 metres and the quays have accommodation for 20 vessels of from 3,000 tons to 6,000 tons. At the same time 21 buoys have been placed inside the port for the safe mooring of 24 vessels.

Along the piers, ten transit sheds have been built by the City. A harbour area railway has been laid from the pier to Shiodome Station. Other necessary maritime installations, such as signal station, bonded compound, cranes, tow-boats and water pipes for the vessels have been provided at the piers. (Figs. 2 and 3).

Imports and Exports

In 1938, the number of vessels entering the port was 3,087, representing a total tonnage of 7,950,000 tons and an amount of goods totalling 7,240,000 tons, both imports and exports, and their total value is estimated at about 9,450,000,000 yen. Furthermore, the amount of goods transported from Yokohama to Tokyo Harbour by lighters and similarly from the neighbouring province of Tokyo, totalled 12,000,000 tons and their value was estimated at 1,300,000,000 yen for the year. (Fig. 4).

Fig. 4. Quay and Shed.

The principal items of imports and exports of Tokyo Harbour are coal, lumber, iron, cement, rice, cereals, sugar and fresh fruit. Tokyo Harbour receives goods from many parts of Japan and many countries of the world, such as Kyushu, Hokkaido, Taiwan, Chosen (Korea) Sagahlien, Kwantung, China, French Indo-China, Straits Settlements, South Sea

Port of Tokyo—continued

Islands, India, Australia, U.S.A., South America and Europe. Thus the port is not simply a domestic trading port and a Customs branch office has long since been located there; some 480,000 tons of foreign goods are handled in this office. In these circumstances it is quite natural that the Tokyo City Authorities should be seeking to include an import and export trading harbour within the City area.

Projected Work

The projected improvement work of the Tokyo Harbour will be completed in the near future. The work consists of the following:—

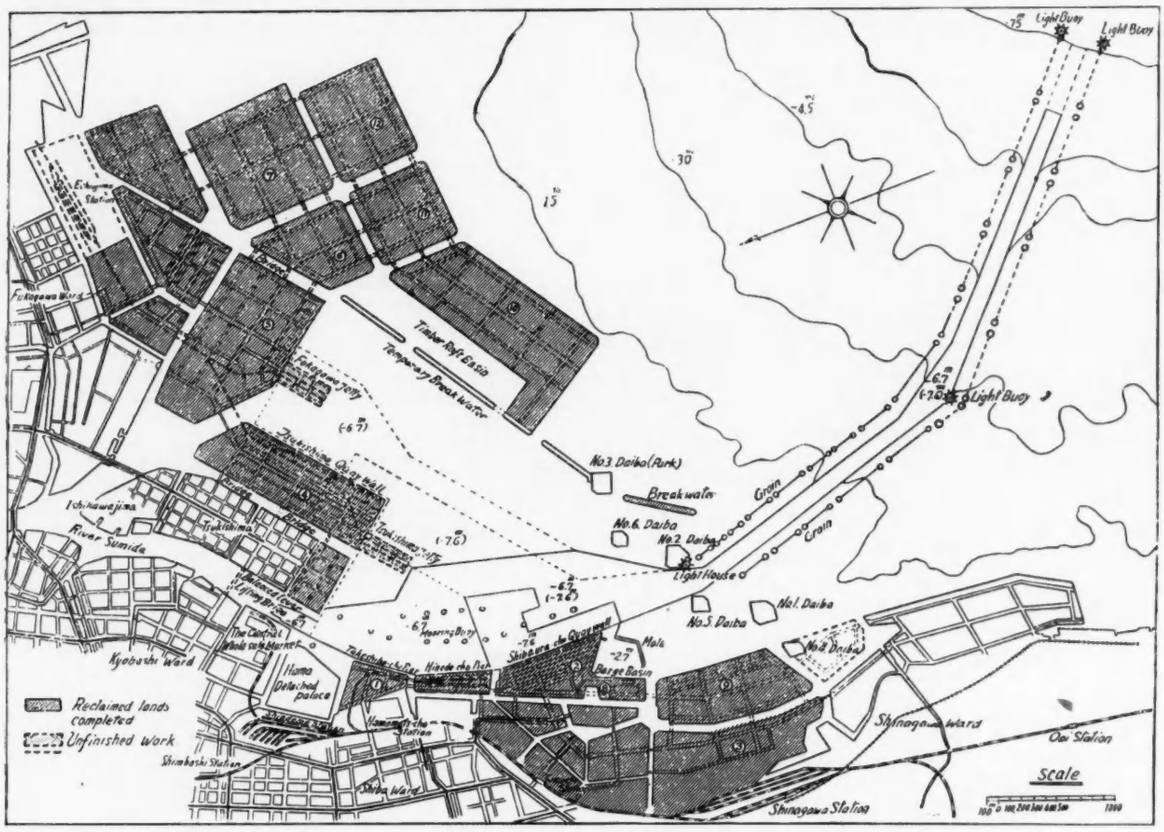
The sea approach is to be enlarged to some 3 miles in length, 110 metres in width, 7.6 metres in depth and jetties and quays at Tsukishima and Fukagawa are to be constructed.

bridge construction in Japan, with three spans, is now under construction to connect the Tsukishima and Kyobashi ward.

This drawbridge is to be named Kachidoki-kyo (Kachidoki bridge); both end spans are of the tied arch type, while a central span, 44 metres long, is a double-leaf bascule. The length of this bridge is 246 metres and the width 22 metres and the moveable span can be operated by two electric motors of 125 h.p. each. The total cost to the Tokyo Municipality is expected to be 4,200,000 yen. Upon completion, it is felt that the spacious reclaimed land will be rapidly developed.

The International Air Port

With the rapid development and progress of aerial navigation in Japan, the city has no adequate air port. The Tokyo Municipality decided to carry out the establishment of a large



Plan of Tokyo Harbour.

The total length of these quays is to be about 2 miles. There are altogether 21 mooring buoys already in the port. Twenty-five more buoys will be placed and the total will so reach 46.

By this means 80 vessels up to the 6,000 tons class will be able to be moored in the port at the same time. Eight sheds are to be newly constructed on the quay of Kaigandori and jetties of Tsukishima and Fukagawa. The harbour area railway tracks are expected to be extended to the quay of Kaigandori and jetties of Tsukishima and Fukagawa.

Management of the Harbour

The management of the Tokyo Harbour is solely under the Tokyo Municipality and up to the present time the city has not asked for any financial assistance. All expenses, such as improvements, have been provided entirely by the municipality.

The Tokyo-Yokohama Canal

Some years ago a scheme for excavating a Tokyo-Yokohama Canal was discussed and the Tokyo and Kanagawa prefectural authorities reached a decision and the work was started.

In this "Keihin" Canal (Tokyo-Yokohama Canal) 22,600 metres in length, from 600 to 700 metres in width, and 9 metres in depth, vessels of 10,000 tons class will be able to navigate safely. On the completion of the work it will not only be suitable for the convenience of transportation between Tokyo and Yokohama, but also the considerable amount of the earth dredged out will serve to reclaim a large area of land. It is expected that this reclaimed land will provide future industrial districts.

Drawbridge

The project is not only to extend the harbour, but also to provide full equipment for land and water communication. A drawbridge, the first of its kind ever built in the history of

International Air Port on the water front of the Tokyo Harbour at an estimated cost of 10,000,000 yen, spread over a period of four years commencing with the year 1938. The anticipated air port is to be established in the reclaimed land adjoining the sea off Joto ward.

"Daiba" or Old Forts.

The "Daiba," six in number, lie across the Bay and add much to the view of the Tokyo Harbour all year round. They are situated in the sea off Susaki and Shinagawa in two rows of three each, but their sizes vary. The first and second "Daiba" each have an area of 33,060 sq. metres, the third about 23,448 sq. metres, the fifth and sixth each have an area approximately 19,836 sq. metres. The second and fifth "Daiba" standing just at the entrance of the harbour are provided with lighthouses and the water police watch both for the safety of the sea traffic.

The sixth "Daiba" is specially protected as a place of historic interest and is kept in its original condition while the third "Daiba" has been opened to the public as a "Park on the Sea." If one stands on the shore of the Bay and looks out over the sea, the "Daiba" looks like just a small islet, but on visiting the same one will be surprised by its size, contrary to expectations.

The distance from Shibaura Pier to the "Daiba" is only a mile-and-a-half, and around there everything is very quiet and peaceful. The climate there is comparatively cool in the summer and is rather mild in the winter and it also has a commanding view of the Tokyo Harbour. The number of visitors to this place is increasing year after year.

Addendum

Tokyo, the capital of Japan, has been almost entirely reconstructed since the disastrous earthquake and fire of 1923, in accordance with a very ambitious and foresighted replanning

Tokyo Harbour

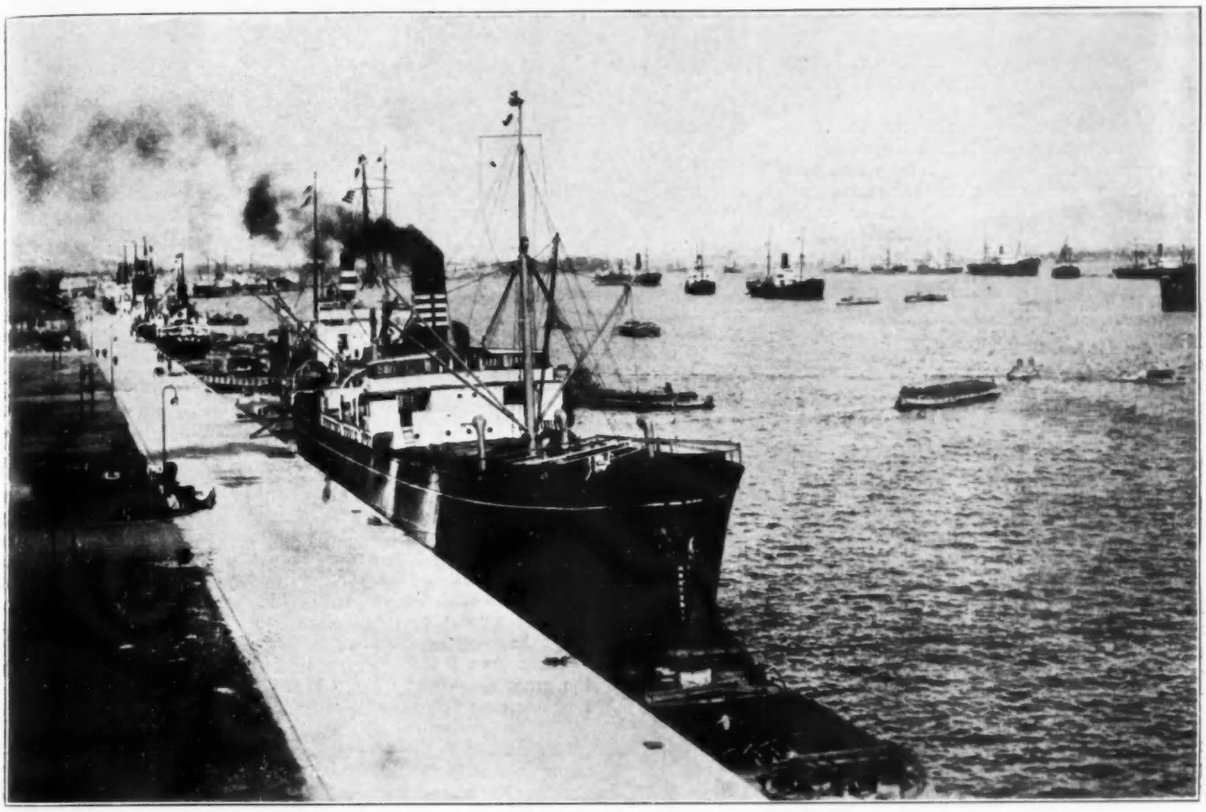


Fig. 2. Kaidori Quay.

Fig. 3. Loading Goods.

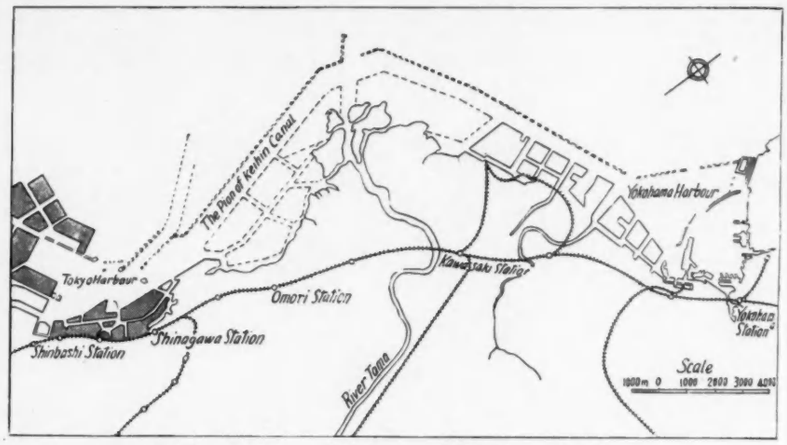
Port of Tokyo—continued

scheme. In 1928 the population was 2,218,000, but the scheme anticipates a total of five millions. Tokyo is situated well up into a gulf known as Tokyo Body and the Port of Yokohama in the same bay has until recently served it as an ocean port for foreign trade, but as is seen by the above account, the City aims to serve the small seagoing ships itself.

Improvement work for the harbour of Tokyo to be completed in the future consists of the following projects:—

For a distance of three miles the ship channel will be redredged to a depth of 7.6 and a width of 110 metres. New jetties and quays will be constructed at Tsukishima and Fukagawa, their combined length to be about two miles. Twenty-five more mooring buoys are to be placed, bringing the total number up to 46. With these additional facilities, 80 ships in the 6,000 ton class can be accommodated in the port at the same time.

Eight new warehouses will be built along the Kaigan-dori and at the jetties at Tsukishima and Fukagawa. The harbour railway will be extended to the Kaigan-obri pierfront and to Tsukishima and Fukagawa.



Relative Positions of Tokyo and Yokohama Harbours.

Some years ago a scheme to dredge a ship canal between Tokyo and Yokohama was proposed, and after consultation with the Kanagawa Prefectural authorities, a favourable decision was reached and work started. This waterway, known as the Keihin Canal, will be 22,600 metres long, 9 metres deep and from 600 to 700 metres wide. When it is completed, ships in the 10,000-ton class can pass along its course. The canal will not only expedite navigation between Tokyo and Yokohama but the dredged earth will be used to reclaim more tracts of land from the harbour floor. The new land areas will serve to augment the present industrial districts of the capital.

Harbour improvements will include the completion of the Kachidoki Drawbridge, a balanced lever lifting bridge built in three spans 22 metres wide, the end spans being of the tied arch type and the middle section a double-leaf bascule 44 metres long. The entire length of the structure, which connects Tsukishima (a reclaimed island) the Tsukiji, Kyobashi Ward, is 246 metres The two movable leaves are operated by a pair of 125 h.p. electric motors. More than two-thirds of the bridge, which is costing the city approximately Y4,200,000, is now completed.

In order to protect the harbour from the open water of Tokyo Bay, a breakwater 2,386 metres in length extends between Reclaimed Land No. 6 and Daiba No. 3. Concrete pile groins that lie on both sides of the ship channel are each 4,380 metres long. They serve to keep the navigation route clear of drifting sand. At the present time the anchorage is from 4.5 metres (15-ft.) to 7.6 metres (25-ft.) deep, and covers an area of 1,450,000 sq. metres within which 21 mooring buoys have been placed.

As facilities to link land and water, there are the Hinode-cho pier, 564 metres in length, and the Shibaura-cho quay, 909 metres long, both built along the Shiba Ward bayfront. The former has been in use since 1916 and the latter was completed in 1932. Transit sheds and railway yards are on the docks at Hinode-cho and Shibaura-cho, but an insufficiency in existing facilities for the port of Tokyo is obvious when it is noted that cargo handled at the Hinode-cho pier alone amounts annually to more than 2,000 tons per linear metre of wharfage, whereas the gross volume of freight from ships moored to buoys in the harbour tops 280,000 tons annually per one buoy.

To-day it is estimated that the total volume of cargo handled at the port of Tokyo has reached a new peak with the continued improvement in facilities available to serve it. This growth has brought about a lessening of the burden on freight traffic at the Tokyo railway terminals.

Developmental work for the harbour has been carried on by the Tokyo Municipality without outside financial assistance. Part of the required construction and operating expenses are being derived from the sale of reclaimed land belonging to the city. A source of additional revenue is charges on new harbour facilities as they are provided.

Notable Port Personalities

V.—Sir Ernest Herdman, D.L., J.P.

Sir Ernest Herdman, Chairman of the Belfast Harbour Commissioners, was born near Belfast, the son of John Herdman, J.P., one of the pioneers of spinning flax by power, previously done on spinning wheels in the cottages throughout Northern Ireland. The family has been associated with the Linen Industry for well over a century.

He was educated at a private school and after having studied in France and Germany, joined as Director the firm of Henry Matier and Co., Ltd., Belfast, in the year 1891 and became Chairman in the year 1935. Shortly before, in 1927, he had joined the Board of the Edenderry Flax Spinning Co., Ltd., Belfast. Other offices filled were those of Chairman of the Belfast Chamber of Commerce, 1926, and President of the Linen Merchants Association in 1931.

Sir Ernest was co-opted a member of the Belfast Harbour Board in 1904 and elected Chairman of the Board in the year 1926, a position which he still holds. He is also Chairman of the (Belfast) Port Emergency Committee.

During his term of office as Chairman, Sir Ernest has fostered and seen great developments of the Port of Belfast, notably the formation of the Herdman Approach Channel and the Pollock Basin.

The dredged spoil from the Harbour and Channel was utilised for the formation of what is known as The Belfast Harbour Air Port. This covers an area of about 400 acres and is within a few minutes drive from the centre of the city. The present Board is pursuing the policy of the enterprising men who, about 150 years ago, started to convert an originally sluggish river into a busy estuary and port which in course of time now takes rank among the five most important in the kingdom.

Sir Ernest was elected President of the Dock and Harbour Authorities' Association, London, for the year 1931, and since that date has been a Vice-President. He is a Deputy-Lieutenant

Sir ERNEST HERDMAN, D.L., J.P.

for the County and City of Belfast and Magistrate for County Down and also for the City of Belfast.

In 1934 the honour of a Knighthood was conferred upon him by His Majesty, King George V.

The Port of London

Review of its Progress by the President of the Institution of Mechanical Engineers

IN his Presidential Address, entitled, "Mainly the Port of London," delivered to members of the Institution of Mechanical Engineers on October 18th last, **Mr. Asa Binns,** Wh.Ex., M.I.Mech.E., said as follows:—

Much has been written about the history of the Port of London, and it is not my intention to give more than a brief sketch to enable the background to be visualised as it was before the formation of the Port of London Authority in 1909.

Whether it is judged by the volume of shipping entering its river, or by the value of the commodities discharged at its quays, London has long been the greatest port in the world. It was the principal port of the country even before it became its capital city. Its great physical advantage is the broad deep river enabling the largest vessels to enter its docks with safety.

During the Roman occupation of Britain, London was the centre of all maritime activity. In Saxon times trade developed and the Danes used the port as a naval base during their occupation. Notwithstanding foreign and civil wars during the four hundred years following the Norman conquest, the trade of the port continued its progress. From the thirteenth century to the close of the reign of Elizabeth, the Hanseatic League did much to foster the trade of the port. During the seventeenth and eighteenth centuries, congestion in the river became more and more pronounced and between 1793 and 1799 a number of schemes for improving the accommodation of the port engaged the attention of Parliament and the mercantile community. After long enquiry, a Committee of the House of Commons reported in 1796 in favour of the construction of enclosed wet

Fig. 1. Dry Dock under construction, King George V Dock.

docks. As a result, the West India Docks were constructed and opened in 1802 by William Pitt, then Prime Minister. Before that date two small docks already existed on the Thames, one of which—the Howland Great Wet Dock, built at Rotherhithe under an Act of 1696—was actually the first public wet dock in Great Britain. The other was the Brunswick Dock, constructed at Blackwall in 1789. Neither of these pioneer docks, however, provided any storage accommodation.

The West India Docks were quickly followed by the London Docks at Wapping, opened in 1805, and by the East India Docks opened in the following year. Meanwhile the Howland Wet Dock was acquired by the Commercial Dock Company, who carried out considerable extensions. The Grand Surrey Canal Company also constructed a basin and entrance lock from the river at Rotherhithe, and a canal leading therefrom to Camberwell and Peckham. These two undertakings, together with their various extensions, were amalgamated in 1865 under the name of the Surrey Commercial Dock Company.

The year 1828 saw the opening of the St. Katharine Dock, and in 1838 the East and West India Docks Companies were amalgamated. After a short lull, the Victoria Dock was constructed and opened for traffic in 1855. In 1864 the London Docks Company and the St. Katharine Dock Company amalgamated and purchased the undertaking of the Victoria Dock Company.

Further competition came with the formation of the Millwall Dock Company, whose docks were opened in 1868. Subsequently the London and St. Katharine Docks Company constructed the extension to the Victoria Dock which was named the Royal Albert Dock. This was opened in 1880, and provoked the East and West India Docks Company to reply with the construction of the Tilbury Docks, completed in 1886.

Fig. 2. Reinforced Concrete Jetties, King George V Dock.

It was evident that the keen competition between the different companies was leading to financial disaster, and in 1888 a combination of the two main companies arrived at a working understanding which culminated in 1901 in the amalgamation of the undertakings under the title of the London and India Docks Company.

With the exception of the extension of the Greenland Dock, completed in 1904, no further works of major magnitude were carried out in the port until after the formation of the Port of London Authority.

The Port Authority's formation was the result of an investigation by a Royal Commission set up in 1900. An Act was passed in 1908 which created the Authority and handed over to it the whole of the docks and the tidal portion of the river. There are twenty-eight members of the Port Authority, of whom eighteen are elected by the payers of dues, and the remaining ten are appointed by public bodies and Government Departments.

The purchase price paid for the acquisition of the docks was about £23,000,000, and since its inauguration, in the course of the past thirty years, the Authority has spent about £20,000,000 more in the improvement of the port. These improvements include the deepening and widening of the river channel, the construction of entirely new dock accommodation, deepening and widening of the older docks and entrances, and the provision of modern equipment. It is perhaps surprising that docks of such antiquity should be capable of improvement to meet modern needs, yet such is the case, and the improvements now in progress at the Royal Victoria Dock, which was opened 85 years ago, will make it one of the most useful docks in the port.

The largest individual piece of new work on which I have been closely engaged was the construction of the King George V Dock, on which I contributed a paper* to the Institution of Civil Engineers in 1923. I propose however to give now for

*Proc. Inst.C.E., 1922-3, vol. 216, p. 372.

Fig. 3. Entrance Lock and Gates, King George V Dock

The Port of London—continued

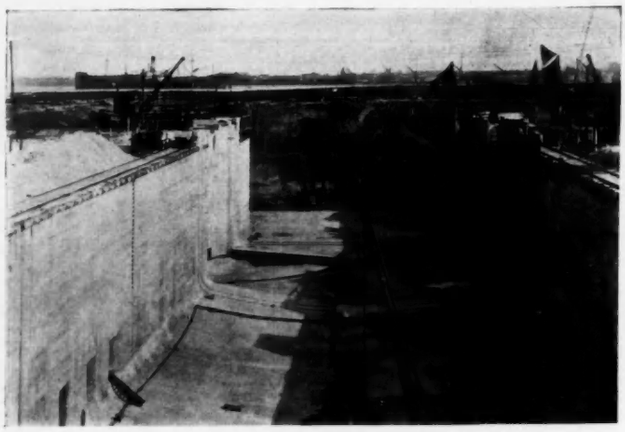


Fig. 4. Entrance Lock under construction, King George V Dock, River End.

the purposes of record, a short description of this important work. It was commenced in 1912 and was opened by H.M. King George V and Queen Mary in 1921. The total cost was over £4,000,000.

The entrance lock is 800-ft. long by 100-ft. wide and is 45-ft. deep at Trinity High Water. It is divided into two compartments by three pairs of steel lock gates. The wet dock has an area of 64 acres with 10,000 lineal feet of quays and provides 14 berths for steamers of the largest size. The dock is well equipped with transit sheds, those on the north side being double-storey of reinforced concrete construction, while on the south side are seven reinforced concrete jetties each 500-ft. long, affording special facilities for overside delivery to barges. The single-storey transit sheds on this quay are of steel and corrugated iron construction.

There is a dry dock 750-ft. long, 100-ft. wide, with a depth of 35-ft. of water over the keel blocks, and there is also a communicating passage between the Royal Albert and the King George V. Docks 100-ft. wide, with a depth of 34-ft.

In the preparation of the contract particulars, a careful survey was made, including cross-sections at intervals of 100-ft., over the whole site; and a series of twenty-eight borings and two trial holes were sunk. The contract for the work was placed with Messrs. S. Pearson and Son, Ltd., in August, 1912, one of the conditions being that the work should be completed in four years. The work was brought nearly to a standstill, however, by the war of 1914-18, and it was not until late in 1918 that the Government granted special facilities for its completion. The contract was then terminated by arrangement, and the Port Authority itself completed the work by direct administration.

In the course of the excavations, several silted-up creeks cutting into the peat were encountered, the largest of these being the old Ham Creek, which was navigable to ships in the seventeenth century. The new works were founded generally on ballast or chalk.

For carrying out the dock contract, electric power was supplied in bulk by West Ham Corporation at a pressure of 6,600 volts, and this was suitably transformed and used for operating pumps, concrete mixers, etc. The whole of the work was carried out in the dry, pumping sumps being provided in suitable positions for discharging the water, either into the river or into the Royal Albert Dock. For long periods, the total pumping averaged about 10,000 gallons per minute, with a maximum of 13,000 gallons per minute.

The main excavation of the dock was carried out by means of Lubecker steam land dredgers, each weighing about 130 tons, with engines of 120 h.p. Under favourable circumstances they were each capable of excavating about 2,000 cu. yards per day. In addition steam navvies were employed for excavation in special places and especially at the entrance lock and the dry dock. About 17 miles of temporary railway were laid over the site, and 16 locomotives were employed to haul 600 wagons of various descriptions.

The surplus excavation was dumped at sea, a distance of 60 miles, by means of hoppers which were loaded by two special tipping hoists in the Albert Dock. Of the total excavation of about 5,000,000 cu. yards, 2,000,000 cu. yards were thus disposed of. Under the best conditions the hoppers carried away about 30,000 cu. yards per week.

The concrete mixers in general use for the mass concrete were of 1½ cubic yards capacity, and were driven by 20 h.p. electric motors. More than thirty cranes were in use on the site, ranging from 5 to 10 tons capacity. Over 3,000 reinforced concrete piles were made on this site, in addition to other pre-moulded sections for the dock jetties, etc. The maximum number of men employed in carrying out the work on the site was 1,700. Over 100,000 tons of cement were used in making the half-million cu. yards of concrete required; and over 250,000 cu. ft. of granite from Cornwall were used for copings, altars, sills, etc.

The dock is equipped with 66 electric quay cranes of 3 tons capacity for handling cargo.

The electrically-driven pumps at the dry dock pumping station are capable of emptying the dry dock in three hours. Each of the two pumps develops 820 h.p. and discharges through a pipe 4-ft. 6-in. in diameter. The lock gates are of steel, and each leaf weighs 350 tons. Six air chambers are provided in each leaf to give the necessary buoyancy. The gates are operated by direct-acting hydraulic rams. The floating caisson, which is used for closing the entrance to the dry dock, weighs over 600 tons, exclusive of the permanent ballast.

There are two moving bridges. The swing bridge over the passage is of the pivot type, 200-ft. long. The total swinging weight is about 1,800 tons, of which 850 tons are kentledge. It is operated by hydraulic power, and the complete operation of opening or closing is performed in 75 seconds. The bridge over the entrance lock is electrically operated and is of the double bascule type. Its weight is about 740 tons, including 360 tons kentledge.

The equipment of the dock is up-to-date in every particular and its popularity with shipowners has ensured the appropriation of every berth for their largest vessels, almost from the date of the Royal Opening in 1921.

Thames Barrage

Passing now from the docks to the river I may recall that during the past hundred and fifty years, barrage schemes with the avowed object of improving the Port of London have been proposed from time to time. Mr. Reveley put forward several projects in 1795 in opposition to the proposed wet docks; Mr. Henry Robinson put a proposal before the Institution of Civil Engineers in 1856; and in 1903 a scheme was seriously discussed for a barrage at Gravesend. In 1934-5 a new proposal was made to install a barrage at Woolwich, and this proposal was seriously discussed in Parliament. A public enquiry was to have been

Fig. 5. Royal Albert Dock, looking East.

Fig. 6. Ship in Dry Dock, King George V Dock.

The Port of London—continued

Fig. 7. Tilbury Entrance Lock, under construction.

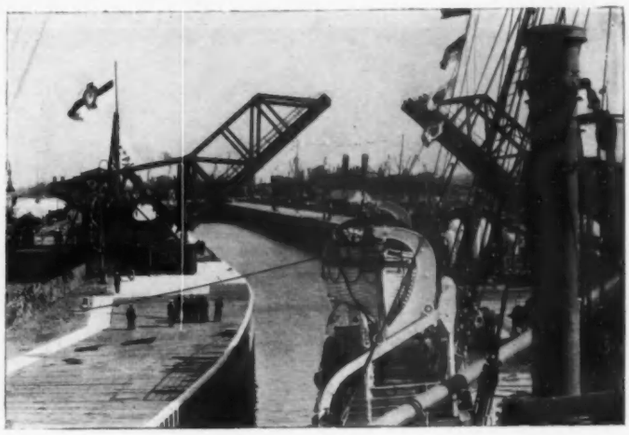


Fig. 8. Tilbury Entrance Lock, completed.

Fig. 9. Refrigerating Station, Interior, Royal Albert Dock.

Fig 10. Cold Store, Royal Albert Dock.

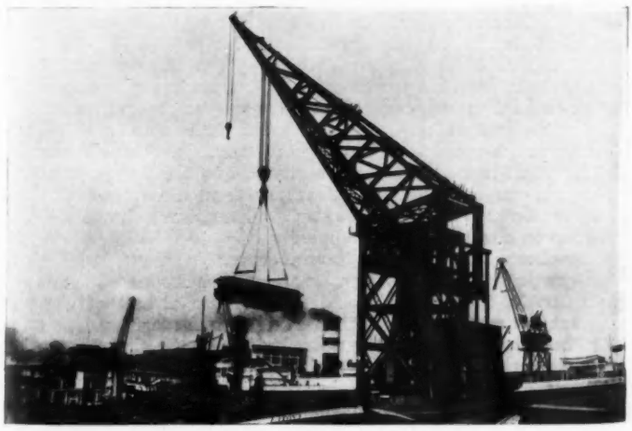


Fig. 11. 150-ton Floating Crane, "London Mammoth."

Fig. 12. Impounding Station, Interior.

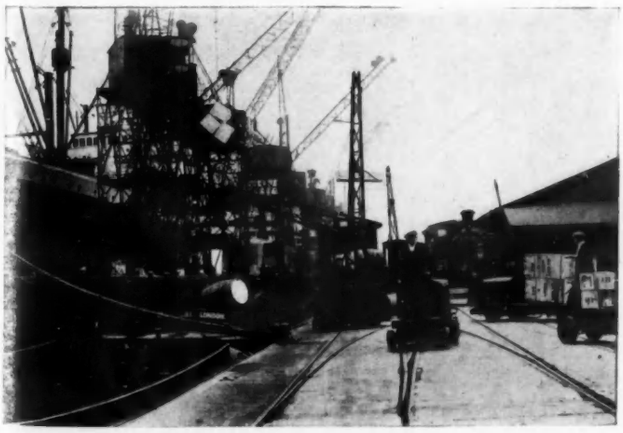


Fig. 13. Mechanized Discharging. King George V Dock.

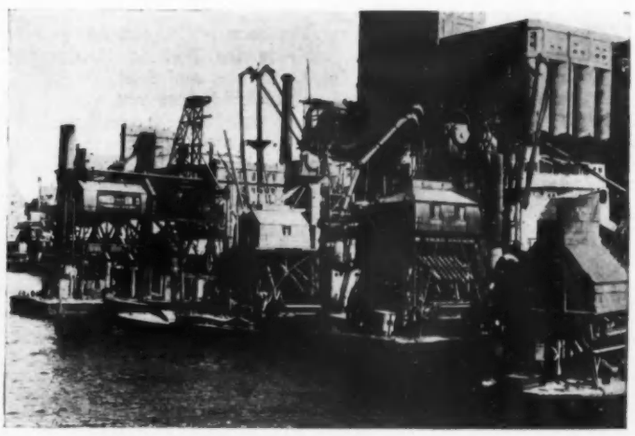


Fig. 14. Discharging Grain by Pneumatic Elevators, Royal Victoria Dock.

The Port of London—continued

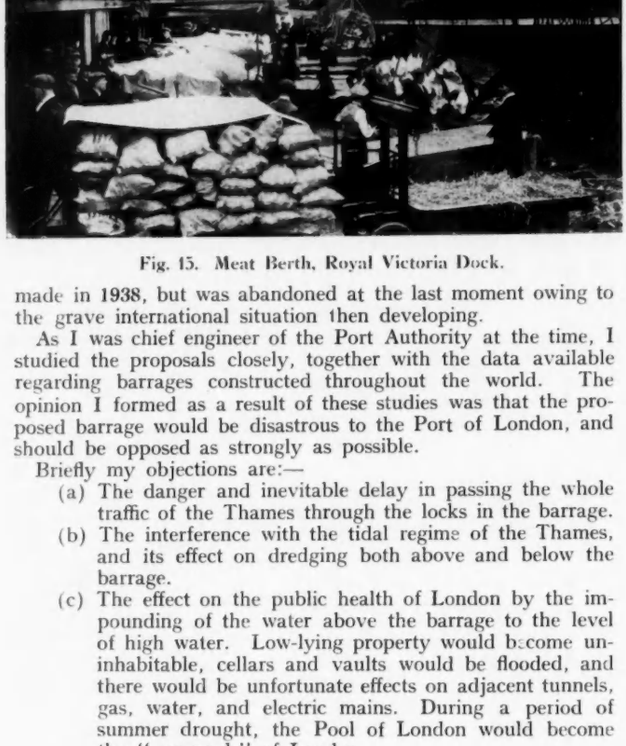


Fig. 15. Meat Berth, Royal Victoria Dock.

made in 1938, but was abandoned at the last moment owing to the grave international situation then developing.

As I was chief engineer of the Port Authority at the time, I studied the proposals closely, together with the data available regarding barrages constructed throughout the world. The opinion I formed as a result of these studies was that the proposed barrage would be disastrous to the Port of London, and should be opposed as strongly as possible.

Briefly my objections are:—

(a) The danger and inevitable delay in passing the whole traffic of the Thames through the locks in the barrage.

(b) The interference with the tidal regime of the Thames, and its effect on dredging both above and below the barrage.

(c) The effect on the public health of London by the impounding of the water above the barrage to the level of high water. Low-lying property would become uninhabitable, cellars and vaults would be flooded, and there would be unfortunate effects on adjacent tunnels, gas, water, and electric mains. During a period of summer drought, the Pool of London would become the " cesspool " of London.

(d) The projects would cost at least £8,000,000; traffic would be gravely inconvenienced during the period of construction; and the working costs of the barrage and attendant staff would put a heavy financial burden on the trade of the Port

(e) The barrage would be a source of weakness in war time, as it would be a target for enemy aircraft and its destruction would paralyse the movement of shipping.

Cold Storage

A great feature of the Port of London is the development of cold storage accommodation. My first experience of refrigeration on a practical scale was at Hull in 1898, where an ammonia absorption plant was in use at the foreign cattle depot, and an ammonia compressor plant was installed by Messrs. Sternes, of Glasgow for the cold storage of frozen mutton. In those days there was a very strong prejudice against frozen meat, and when the junior engineering staff at the Hull Dock offices bought and shared a frozen lamb, my landlady almost wept at the fancied desecration of her oven when she was asked to roast the frozen joint for the Sunday dinner.

The London Docks were pioneers in the provision of cold storage accommodation, their first store being opened at the Victoria Dock in 1881. In 1897 the late Sir Hay Frederick Donaldson read a paper* before the Institution of Civil Engineers, entitled " Cold Storage at the London and India Docks." Since that date great progress has been made, and fine storage accommodation is now available in the Port for frozen and chilled meat, fish, bacon, dairy produce, and fruit.

During the war of 1914-18, a new cold store was constructed at the Royal Albert Dock with accommodation for half-a-million carcasses of mutton. In peace-time, and even more in war-time, cold storage is now a national necessity for ensuring a regular supply of food in sound condition.

In earlier days, the storage space was usually cooled by the circulation of cold brine, but in later installations cold air is circulated by means of suitable air ducts, and the use of charcoal and slag wool as insulating media has largely been superseded by the use of compressed slabs of granulated cork.

Mechanisation of the Docks

Members of this Institution will be interested in mechanisation as applied to dock operations. Manual dock labour from the power-producing point of view is from 100 to 200 times as expensive as mechanical power at the rates of pay prevailing in London. This disparity would appear to warrant almost unlimited mechanisation, but this is a fallacy. The dock labourer is flexible and can carry out all sorts of instructions, and is in fact highly skilled in many directions. Mechanical plant on the other hand means heavy capital and maintenance charges, and can rarely be employed for an average of twenty hours per week all the year round. For example, the 150-ton floating crane, " London Mammoth," cost about £80,000. Capital charges, including depreciation, amount to about £12,000 per annum, or say £40 per working day. Operating expenses, including crew, fuel, maintenance, etc., will add another £40 per day; and, as the number of heavy lifts required is small, it is obvious that the charges for the use of the crane cannot be remunerative. Such a crane is essential in a first-rate port, however, and helps to attract and retain revenue-producing trade.

In contrast to the heavy floating crane, there are several large flour mills at the docks which work night and day six days a week all the year round. Complete mechanisation, from the pneumatic discharge of grain from ocean-going steamers berthed alongside to road deliveries of flour by motor vehicles, is warranted by the high load-factor obtainable. Apart from general purpose appliances, such as quay cranes and electric trucks, special plants are being more and more used for handling bulk commodities such as grain, meat, fruit, cheese, and tobacco.

Dock Construction by Modern Methods

In new dock construction an important factor is that of mechanical plant. In the early nineties of last century, the late Professor John Goodman took his engineering students at Leeds over part of the Manchester Ship Canal, then in course of construction, and I was greatly impressed not only with the character of the finished work but also with the variety and scope of the plant employed.

The plant was then almost entirely steam-driven; to-day we mostly employ electric power and the internal combustion engine. Reinforced concrete construction was then unknown in this country. I remember the curiosity with which I inspected the cropped end of a reinforced concrete pile sent to the Admiralty by Messrs. Mouchel from Southampton about the end of last century. Now the dock engineer employs reinforced concrete very largely, not only for foundation piles but for jetties, warehouse construction, and many other purposes. Steel sheet piling is another modern development which is largely used both for temporary and permanent work. Pile-driving plant, concrete batching, concrete pumping and vibrating plant have developed out of all recognition during the century.

The use of concrete monolith construction, the lowering of ground water level by pumping from a series of filter wells, and the consolidation of ground by chemical impregnation, are helpful developments in dealing with foundations under difficult conditions. The use of compressed air on foundation and tunnelling work is much better understood, and the danger to the workmen can be overcome by proper precautions. All types of excavating machinery, including dredgers, have shown much progress in size, speed and reliability.

Notwithstanding all these improvements in plant, and advantages in method of design, together with improved quality of materials, it should be noted that the capital cost of heavy construction works has more than doubled in the last forty years, and there has been little or no reduction in the time required for the work to be carried out. What can be claimed, however, is that difficult works can be carried through with much more assurance of success and freedom from accident, and that the design and quality of the finished work is better and more lasting.

Fig. 16. Discharging Meat at the Jetties, King George V Dock.

*Proc. Inst.C.E., 1896-7, vol. 129, p. 1.

Notes of the Month

New Floating Dock at San Diego.

The expenditure of a sum of $1,250,000 has been authorised by the U.S. House of Representatives for a new floating dock at the port of San Diego, California.

Cowes Harbour Board.

Mr. E. C. Redman of the firm of A. H. Cobbold and Co., Southampton, has been appointed a Commissioner of Cowes Harbour in place of the late Mr. Cyril Sharp.

Chinese Foreign Traffic.

The total tonnage of shipping entered and cleared in the foreign trade at all Chinese ports during the first half of the current year was 13,301,656. More than half this total was under the Japanese flag.

Mayoralty for Railway Port Official.

Councillor J. H. Swallow, who is Mayor-Elect of Newport, Mon., was, until his recent retirement from the service of the Great Western Railway, deputy chief docks manager. His brother is manager of the Barry Docks.

Reopening of Dublin Dockyard.

The Dublin Dockyard, covering an area of about eight acres at the North-west corner of the Alexandria Basin, has been re-opened on a lease of 50 years granted to a new company by the Dublin Port and Docks Board.

Death of Irish Port Board Member.

The death has occurred of Mr. Philip J. Lawrence for many years a member of the Dublin Port and Docks Board, and a former chairman, from 1928 to 1930. Mr. Lawrence was largely responsible for the extension and completion of the deep-water quay, as well as for other improvements at the port.

Finances of Stockton Quay.

The accounts, recently published, of the Corporation Quay at Stockton-on-Tees, for the year 1938-9, show a gross profit of £1,821. This satisfactory result marks the turning of a financial corner and the conversion of an unremunerative asset into a paying concern.

Death of Harbour Commissioner.

The death is announced at the age of 73 of Mr. Archibald Miller, for nearly six years a member of the Southampton Harbour Board as a representative of the trader electors. Mr. Miller was formerly manager at Southampton for the Clyde shipping Company, Ltd.

The Amalgamated Danube Commission.

Negotiations between German, Italy, Roumania and Russia have resulted in a scheme for a new Amalgamated Danube Commission to supersede the former European Commission of the Danube with a much wider representation of Continental countries. The inclusion of Russia, not a member of the original International Commission, has been the subject of a protest by Great Britain to Russia which the latter has rejected.

Dock Labour at Hull.

Hull has now come into line with other ports in the matter of the engagement of casual labour at the docks. Under a long-established custom, casual dock workers, numbering about five thousand, used to congregate at the quayside, where they were "set on" for ship discharge. All such labour is now recruited by the stevedores at special calling-on stands, as is the practice in connection with the new compulsory registration scheme adopted at other ports.

The St. Lawrence Deep Waterway Scheme.

Arising out of defence measures for the United States and Canada further progress is likely to be made at an early date on the scheme for providing a ship channel in the Upper St. Lawrence, though the steps to be taken will, for the present, be limited to the development of hydraulic power, which is a collateral object of the proposed undertaking. The navigational side has already been inaugurated by the construction of the Welland and Beauharnois Canals.

New York New Dry Dock.

The site for the new 1,200-ft. dry dock at New York has been fixed at Bayonne, New Jersey. This decision was reported to the United States House of Representatives Appropriation Committee by Rear-Admiral Moveell. The dry dock will be constructed at the Naval Supply Depot which it is proposed to establish at the Municipal Terminal at the Port of Bayonne. The city has agreed to sell the site for about $2,500,000 which represents the approximate value of the municipal investment.

Port Dues at West Hartlepool.

The balance of the 30 per cent. rebate formerly allowed to shipowners on the schedule of port dues having been withdrawn in October, the full statutory rates are now levied.

Floating Dock for Murmansk.

A reinforced concrete floating dock of 4,000 tons lifting capacity is reported to be in course of construction at Leningrad for service at the Russian Arctic port of Murmansk.

Resignation of Conservancy Commissioner.

Alderman F. Barrett, of Grimsby, has been compelled from reasons of health to relinquish his seat on the Humber Conservancy Board. Alderman Barrett had been a member of the Board since its formation.

Rothesay Harbour Trust.

The following gentlemen, representative of shipping interests, have been elected to Rothesay Harbour Trust: Messrs. C. A. Bremner (L.M.S., Gourock), Capt. H. A. Berry (L.N.E.R., Glasgow), John A. Rodger (Clyde Cargo Co., Glasgow), and John Hogarth (Rothesay).

Oil Refinery Installation at Port Arthur.

Port Arthur, Texas, U.S.A., has recently been equipped with additional oil refining plant, enabling it in conjunction with the existing installation at Port Neches in the adjoining area, to deal with 196,000 barrels of crude oil daily.

Extension at Port of Chofu.

The American Consulate at Kobe has reported that extensive improvements are in hand at the Port of Chofu in Western Japan. The programme covers a period of ten years and makes provision for the accommodation of 37 ships of large calibre (10,000 tons).

New Port in Washington State.

Construction of a new inland port for sea-going vessels is being undertaken at Camas-Washougal, in the State of Washington, U.S.A. Located 21 miles below the notable Bonneville Dam at a point 128 miles up the Columbia River, is expected to be ready for shipping in the spring of next year (1941).

Charter for Dockers in France.

It is reported that a dockers' charter is being drawn up by the Vichy Government. It will place dockers under Government authority with the object of avoiding strikes. All dockers will in future have to have a card before they can be admitted to the docks or on ships to be handled.

Death of Former Dockmaster.

The death at the age of 81, is reported of Captain G. N. Belton, formerly in the service of the Millwall Dock Company and of the Port of London Authority. Captain Belton was assistant dockmaster at Millwall and subsequently dockmaster at Tilbury.

Petsamo as a Postal Port.

Owing to the difficulty experienced by the Swedish postal authorities in obtaining a communication route with the West, in consequence of the German occupation of Norway and Denmark, Petsamo, the Finnish Arctic port has acquired considerable importance for Swedish postal services. The American parcel post used this route for some time, but it has latterly been discontinued.

Registration of Larne as a Port.

The Larne Borough Council have petitioned the Registrar-General of Shipping to register Larne as a port. A sub-committee which dealt with Larne's claims for registration submitted figures relating to the number of Larne-owned vessels and fishing craft and the tonnage passing annually into Larne, and pointed out that, according to its present shipping status, Larne was described as a "sub-port or creek."

Swedish Port Labour.

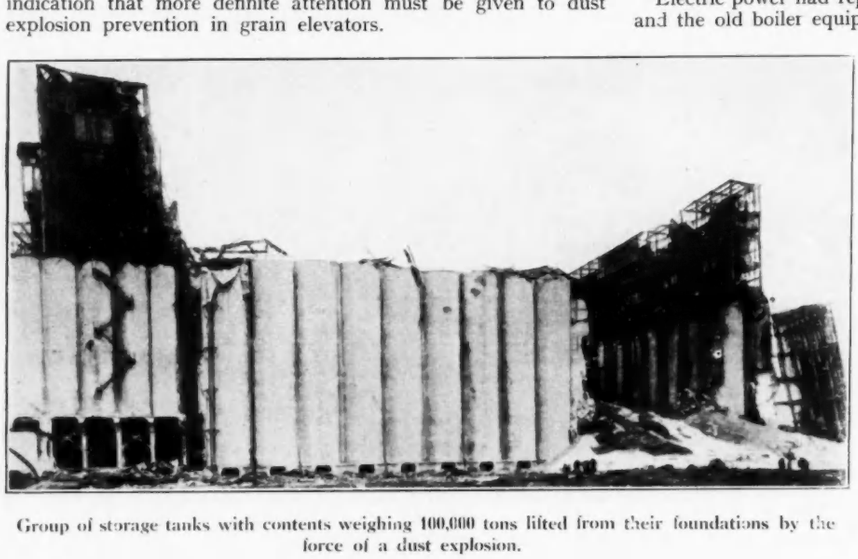
The Swedish Dockers' Union are complaining that since the German invasion of Denmark and Norway, and the closing of the Skagerak which severed Swedish ports from trade overseas, there has been serious unemployment among port workers. Gothenburg, in particular, appears to have suffered severely and half of the membership roll of the union at that port are or have been lately in the category of constantly unemployed. Stockholm reports a condition of affairs very little, if at all, better. It appears to be the unfortunate fate of neutral nations to suffer almost as great evils from their "neutrality" as if they had thrown in their lot with the belligerents.

Dust Explosions in Terminal Grain Elevators†

The Causes and Methods of Prevention

By DAVID J. PRICE* United States Department of Agriculture.

ALTHOUGH losses from dust explosions have been reduced materially in the food-manufacturing industries which have co-operated in working out and adopting practical safety and preventive measures against dust explosions and resulting fires, there is still need for more definite attention to the application of methods for the control and prevention of dust explosions in grain elevators. Since 1930, 56 grain elevator explosions have been reported. In these explosions 40 people were killed, 145 were injured, and the property losses amounted to more than $7,500,000. These 56 explosions were almost 36 per cent. of the total number of explosions reported during the period. This is a positive indication that more definite attention must be given to dust explosion prevention in grain elevators.



Group of storage tanks with contents weighing 100,000 tons lifted from their foundations by the force of a dust explosion.

Effect of New Manufacturing Processes

Although considerable progress has been made in the U.S. and Canada in the control and prevention of dust explosions in grain handling and milling operations, it must be admitted that all possible causes of dust explosions are not positively known. Dust explosions may occur in an industrial plant as a result of some newly-developed type of mechanical or electrical equipment. Many of the dust explosions in recent years in the U.S. have been directly associated with the introduction of new manufacturing processes which have opened up additional sources of ignition and have resulted in conditions favourable to explosions. It is therefore highly desirable that new manufacturing operations be carefully examined to detect possible dust explosion hazards, and that attention be given to the adoption of preventive measures.

Explosion at Chicago Grain Elevator

The dust explosion and spectacular fire in Chicago on May 11th, 1939, caused the loss of nine lives, more or less serious injury to about 30 men, and a property loss of about $3,500,000. The initial explosion occurred about 8.25 a.m. in Calumet Elevator A, owned by the Chesapeake and Ohio Railroad Co. and operated by Rosenbaum Brothers. The fire which followed spread to Elevator B, also known as Elevator A Annex, and to Elevator C of the Rosenbaum group, and then jumped across a slip and ignited two other elevators operated by the Norris Grain Co. All elevators were located along the Calumet River between 102 and 103 Sts. The elevators were built in 1894 and 1895 and were of the old style metal-clad frame construction with crib bins. The destruction of the five wooden elevators and their contents was almost complete. A section of concrete grain storage tanks alongside Elevator A and portions of brick buildings formerly used for power houses, when the elevators were operated by steam, remained standing. Only a small amount of the grain in storage was salvaged.

Description of Plant

Many changes and improvements had been made since the buildings were constructed, particularly in providing additional fire protection during recent years. Automatic sprinklers had been installed, and provision made for water curtains on the exposed sides of the Calumet Elevators. The Norris Elevators were not provided with sprinklers. The concrete storage tanks were erected in 1930 and were connected to Elevator A by concrete belt tunnels at the basement level and by steel frame, metal-clad belt galleries at the level of the top of the tanks. Guillotine doors operated by fusible links were provided to prevent the spread of fire through the tunnels.

Electric power had replaced steam power in the elevator plant and the old boiler equipment had been dismantled. The boiler house was used for shop work and to house the fire pumps. Electrical equipment probably was well above the average, with wire in conduit, vapour-proof lights, and dust-proof and non-sparking motors. Dust-proof switch and fuse cabinets were generally used. Squirrel-cage motors were used in the concrete tank section, and some old-style fuse cabinets had not been replaced. Motors were grounded.

Elevators A and B were connected by a steel frame, metal-clad belt gallery for the transfer of grain from one house to another, and Elevators B and C were connected by a concrete belt tunnel for the same purpose. Equipment in all houses was largely of wood. Scales and garners were of wood. Elevator legs and heads were of wood, but boots were of metal.

A grain drier with brick walls about 3 storeys high was located east of Elevator A. It was connected to Elevator A by several spouts and a frame-enclosed belt gallery or tunnel at the ground level. A metal-clad, frame dust house located east of the drier also was connected to Elevator A by spouts or ducts from the cleaning floor located about the middle of the bins in the south-east corner of Elevator A. Fans on cleaners, clippers, and separators, located in this cleaning room discharged to the dust house. Floor sweeps in Elevator A connected to a fan on the first floor which discharged to the dust house.

East of the concrete storage tanks was a truck dump arranged to receive grain brought to the elevator by trucks. In this sheet metal building was installed equipment to lift trucks and discharge their grain into a hopper connected by conveyor belts with the belts in the basement of the storage tank section. Two of these belts were operating in concrete tunnels.

Details of the Explosion and Subsequent Fire

Information available indicates that the men had reported for work about 8 a.m. and from the superintendent of the elevators, the foreman, and one employee who escaped, information was obtained concerning the operations in progress in Elevator A at the time the explosion occurred. Neither the superintendent nor the foreman was in the elevator at the time, but they described the operations they believed were being carried on as follows:—

1. The day before the explosion occurred several truck-loads of corn arrived at the elevator. All but one had been unloaded on the truck dump east of the concrete tanks by quitting time. When operations were resumed the next morning six elevator legs—Receivers 1, 2 and 3 and Shippers, 3, 4 and 5—were started in Elevator A; the conveyor belts from the truck dump to the basement of the concrete tanks and through the tunnel to Shipper 4 were started and the truck-load of corn held over from the day before were emptied. This corn travelled over the conveyor belts to the boot of Shipper 4, was elevated, weighed, and spouted to a bin. As far as is known, no distributing belts were operating in Elevator A. This particular grain-handling operation had been completed prior to the explosion, because the information available indicates that the trucker, after unloading at the dump, drove to the elevator office where he was advised of the weight and had left the premises.

†The article is reproduced by permission from the May, 1940 issue of "World Ports."

*Dr. Price is the principal engineer in charge of the U.S.A. Chemical Engineering Research Divison, Bureau of Agricultural Chemistry and Engineering. He is chairman of the National Fire Protection Association's Committee on Dust Explosion Hazards.

Dust Explosions in Terminal Grain Elevators—continued

The elevator employee in charge of the truck dump had shut down the conveyor belt leading from the dump into the concrete tank section and had entered the basement of the tank section to shut down the belt which carried the grain through the tunnel to the boot of Shipper 4 in the basement of Elevator A. His statements before he died and the evidence available indicate that he was at a point under the tanks along the north side and about one-fourth of the length of the basement from the east end.

2. On the day before the explosion some wheat was transferred from Elevator B to Elevator A and a part of this lot of grain was held in the upper cleaner bin. As described previously, the cleaning room was located about halfway between the ground floor and the top of the bins at the south-east corner of the bin section; the portion of the original bin above this room was known as the upper cleaner bin, and the portion below the room was known as the lower cleaner bin. At the time the explosion occurred the grain which had been held for cleaning was being run through the cleaner into the lower cleaner bin, and from it to the boot of one of the shippers which elevated it for distribution to designated bins. It was indicated that either Shipper 3 or Shipper 5 could be used and both were running.

3. Some sweeping was done at the south-east corner on the first floor of Elevator A. The employee who escaped from this section of the plant advised the investigators that he was sweeping on the east side of Shipper 5 and another employee was sweeping on the west side of the leg. He stated that the first flash of fire came out of Shipper 5. It is assumed that one shipper leg was used to elevate the clean grain from the cleaning operation described under 2, and another leg was used to elevate the screenings from this operation and the material swept up on the first floor.

Operations in other sections of the plant, particularly Elevators B and C, had no bearing on the cause or origin of the explosion. Although some grain-handling operations were in progress in these houses, the explosion did not propagate to them, and it was some time before they were ignited by the fire which followed the explosion in Elevator A.

Some repair operations were in progress in the drier building directly east of Elevator A, but the two men engaged in this work escaped without being burned or injured. The dust house located east of the drier was not involved in the original explosion. One man was at work in the building, according to information furnished the investigators, and he escaped without injury.

Origin of the Explosion

From the evidence obtained in an inspection of the ruins and statements of employees, it is believed that the explosion originated in the boot of Shipper 5. This leg may have been handling screenings from the cleaners. The fact that the men on the first floor were sweeping into this boot would indicate that a certain amount of dust was present in the leg.

The tunnel through which the conveyor belt ran from the basement of the concrete tanks to the boot of Shipper 5 was examined as far as possible from the tank end and was found to bear more evidence of fire than could be noticed in other tunnels. Charred dust on the curved concrete wall where this tunnel entered the tank basement indicated that the flames propagating from the basement of Elevator A were deflected toward the east end of the tanks, where they entered the steel leg and its concrete enclosure. Of course there was some flame propagation in other directions, but the evidence would indicate that the principal paths of travel were northward through the tunnel from the boot of Shipper 5, westward through the first floor of Elevator A, and upward to the cleaner room and through the leg to the upper floors of Elevator A.

Possible Causes of the Explosion

Although there was considerable evidence that the cause of this explosion may have been associated with the unloading of the truckload of corn at the truck dump each of the concrete tanks, it was not possible to establish this operation as the most probable cause. It was assumed that foreign material in the corn might have caused a spark when it entered the conveying and elevating machinery. It was suggested also that the truck in starting may have backfired and ignited dust which fell on to the conveyor belt and was carried into the elevator. Electric sparks from the motors or starters on the conveyor belts from the truck dump also were cited as possible causes. The fact that the truck-dumping operations had been completed sufficiently long before the explosion occurred to permit the weighing of the load and the delivery of the weight ticket to the driver at the office, and the fact that he had left the premises precluded the establishment of these possible sources of ignition as the most probable cause of the explosion.

The complete destruction of Elevator A made it impossible to determine the condition of equipment in which the explosion is believed to have originated. With the lines of propagation centering at the boot of Shipper 5, it is believed that this part of the grain-hauling equipment was the point of origin, and the most probable cause of the initial ignition was foreign material entering the boot either from the cleaners or from the work floor.

Conclusions and Recommendations

All of the elevators involved in this explosion and fire were of the old style wooden type, which made it impossible or impractical to comply with many of the suggestions in the terminal grain elevator safety codes. Unusual precautions had been taken for the prevention of fire, but this case demonstrated again that an elaborate sprinkler system can be rendered useless by an explosion. It is believed that it might have been possible to provide some protection in Elevators B and C it power could have been maintained at the fire pumps and control valves to cut out the damaged sections had been available. Where sprinkler systems are subject to the explosion hazard, it is suggested that underground power lines to the pumps be provided and that remote control valves be installed to cut out damaged sections of sprinkler piping.

Destruction of five grain elevators at Chicago by explosion and fire resulting in a loss totalling $3,500,000.

The increased use of motor trucks for the transportation of grain, and the hazards incident to their operation in dusty atmospheres, emphasise the need for further study of this problem. In some cases it is known that tilting of the truck to unload the grain may cause gasoline to spill from the tank of the carburettor. After long runs with heavy loads the exhaust pipe and muffler of trucks may be hot enough to ignite dust. A backfire when the truck is started after unloading would be capable of igniting dust deposits around the dump. If this method of grain handling is used at an elevator, it is recommended that all possible precautions be taken to eliminate the sources of ignition mentioned.

The regulations which prohibit the application of suction before weighing grain entering an elevator prevent the elevator operator from providing adequate protection. Foreign material in grain received at an elevator is frequently of a type which may produce sparks if it enters the grain-handling machinery. Dust accumulated in the grain during previous handling operations must be received into the house with the grain and weighed. It is suggested that attention be given to the possibility of developing some system whereby dust removal during the handling of grain could be under supervision to prevent abuses. Dust could be caught in a bag and the bag included with the shipment where it is necessary to maintain weights. Some provision must be made to remove the incentive for elevator operators to return to the grain dust removed during handling operations in order to maintain their incoming and outgoing weights. It will be necessary to develop and install effective methods for dust collection and dust control in grain elevators in order to reduce dust explosion losses in this industry. Until this is done it will not be possible to make progress in dust explosion control in terminal grain elevators comparable with what has been already accomplished in the control of the dust explosion hazard in other grain and milling industries.

Dust Control in Grain Elevators

It must be recognised that the most disastrous losses from dust explosions are occurring in terminal grain elevators and that satisfactory progress has not been made in the control of dust explosions in this branch of the grain-handling industry. Much of this can be assigned to the lack of provision for adequate dust control during handling, storing and shipping operations.

In considering this matter several years ago when it was apparent that extensive losses were occurring, the Bureau of Chemistry and in the Department of Agriculture learned that

Dust Explosions in Terminal Grain Elevators – continued

many of the dust-collecting systems installed in grain elevators throughout the U.S. could not be used, or were dismantled because of the objection of the officials having jurisdiction over the weighing of the grain. The weighing departments stated that grain weights were greatly affected by the action of suction used in the collection of the dust. Reports of tests conducted by a number of elevator operators, however, indicated that the weight of the dust removed is almost negligible. Some men experienced in grain handling stated that less dust is removed by suction than is lost in handling grain by means of poor machinery, with no dust-collecting equipment.

Confronted with these conflicting statements, the Bureau of Chemistry made a preliminary study of the effects of dust collection on the weight of grain. The results of this study showed that much depended on the design and installation of the dust-collecting equipment. In many cases the equipment seemed to have been installed with no knowledge of the fundamentals of good design. In some cases the claims of weighing departments that grain had been drawn out by improper application of suction to remove the dust at certain points between the car which was being unloaded and the scales probably were correct. No information concerning a generally accepted method of applying suction or the proper equipment to use could be obtained. Every elevator seemed to have its own system of dust control and no standards existed. None of the systems was so installed as to permit inspection, nor was any so designed that it would be impossible to lift grain by increasing the speed of the fan, with a corresponding increase of suction.

The results of these preliminary investigations showed the necessity for a detailed study of the problems of controlling dust conditions in grain elevators. U.S. Department of Agriculture Bulletin No. 1373 entitled " Dust Control in Grain Elevators," by Hylton R. Brown and J. O. Reed, published in February, 1926, and revised in March, 1928, contains the results of these investigations.

Since the explosion at the Rosenbaum Grain Elevator in Chicago, which was referred to earlier in this article, three major grain elevator explosions have occurred under similar circumstances. At Houston, Texas, on December 3rd, 1939, an explosion occurred while wheat was being turned. The ignition evidently occurred in a bin through which the grain was falling and is believed to have been caused by foreign material striking sparks on the bin wall. Provision for venting explosion pressure prevented structural damage to the plant but the loss amounted to about $75,000. No one was injured.

On January 3rd, 1940, an explosion occurred at the Hart Bartlett Sturtevant elevator in St. Joseph, Mo., while corn was being turned. No one was injured in this explosion, but the property damage amounted to about $20,000. Foreign material in the grain is believed to have been responsible for this dust ignition.

The Burrus elevator at Kingfisher, Oklahoma, was seriously damaged by a dust explosion on February 14th, 1940, while corn was being turned. One man was killed, three others were injured, and the property loss was about $50,000. The explosion blew out on the side of the leg well and reduced the head house above the bins to a mass of broken concrete and twisted steel.

The similarity of these explosions emphasises the necessity of taking all possible precautions to control the dust in grain-handling operations and to develop methods of preventing dust ignitions.

Methods of Dust Control

The dust conditions in a grain elevator are effectively controlled only when:

(1) Dust clouds are eliminated at their point of origin by the application of suction.

(2) Dust accumulations are promptly removed from the building, either by a vacuum cleaning system or by a floor-sweep system.

(3) The elevator and equipment are well ventilated.

The mechanical methods of controlling dust conditions can be divided into: (1) dust collection; (2) dust removal; (3) ventilation.

(1) Dust collection deals with the methods of removing dust clouds at their source by means of induced air currents, supplied through specially designed hoods connected to a fan system.

(2) Dust removal deals with the methods of removing static dust, that is, dust which has settled and accumulated on the floors, walls, equipment, etc.

(3) Ventilation can be divided into natural ventilation and mechanical ventilation.

Coastal Lighting in the U.S.A.

The following particulars of the Lighthouse and Lightship Service in the United States of America are given in a booklet entitled " United States Coast Guard," issued by the U.S. Treasury to mark the 150th anniversary of the service:

There are over 500 fully attended lighthouses. Many of these, in addition to the powerful lights displayed from their lanterns, are also fitted with fog signals, some to broadcast radio-beacon signals on fixed schedules and in time of fog, and have facilities for distance finding purposes. There are several thousand automatic lights marking the intermediate points on the coasts and the many miles of interior waterways. The most powerful marine light in the United States is that at the Navesink Lighthouse on the highlands of New Jersey overlooking New York harbour, having a candle power of 9,000,000.

There are 31 lightship stations. A ship remains constantly on each of these stations, and about 10 vessels, known as relief lightships, are held in reserve. Ships are fitted with propelling machinery of considerable power, all signals are power operated, and the ships can remain on station for as much as a year without relief.

The Coast Guard maintains the International Ice Observation and Ice Patrol Service, and provides, early each summer, a patrol of seagoing cutters, the duties of which consist of the maintaining of a look-out for icebergs, the observation of weather conditions, the collecting of meteorological and oceanographical data, and the dessimination of pertinent information to shipping directly by means of radio and also through other official agencies.

More than 20,000 buoys, marking the channels of the navigable waters of the United States, the approaches to harbours, and the great mileage of the interior rivers and lakes are maintained.

Ocean-going cutters are on stations lying between the United States and Europe, in the general vicinity of Bermuda and the Azores, for the purpose of supplying data on mid-ocean weather to the United States Weather Bureau. Ships assigned to this duty carry trained weather observers and specialised equipment for the work in hand, including balloons and other gear used in radio sonde observations in the upper air. Meteorological work is also an important part of the activities of the cutters which maintain the International Ice Patrol.

Each winter the Coast Guard is called upon to open countless icebound harbours, to break channels to large numbers of ships which have been caught in rapidly-forming ice, and to deliver supplies to communities cut off from their normal means of communication. In recent years ships have been specially designed to fit them for such service.

The Coast Guard Reserve is an organisation, on a purely voluntary basis, of groups of small boat operators in all parts of the country, for the primary purpose of promoting the safe operation of small craft and of equipping these craft beyond the ordinary requirements of existing law for the greater promotion of safety at sea.

There is a patrol of cutters in the waters of Alaska, including the North Pacific Ocean and Behring Sea, for the purpose of assisting persons and vessels in distress, protection of the seal herds, the sea otter, walrus and sea lions. A typical Behring Sea Patrol was carried on by eight vessels which cruised 64,032 miles during the 5,761 hours which they were under way.

There are over 140 radio-beacons, at all lightships and at many important lighthouses, along the coasts of the United States and upon the Great Lakes

Obituary

The death of **Mr. Garnham Roper, C.B.,** at the age of 78 removes a Government official whose signature for a number of years was familiar in port circles. As Assistant Secretary and Pilotage Commissioner of the Board of Trade, it fell to him to issue circulars of instructions which had a wide application in harbour matters. Mr. Roper entered the Civil Service in 1885 and received an appointment at the Admiralty, from which he was transferred to the Board of Trade in 1888. He spent five years in the Marine Department, in the course of which he acted as secretary to several departmental committees and to the Royal Commission on Electrical Communication with lighthouses. In 1903, Mr. Roper was transferred to the Harbour Department, and in 1913 became an Assistant Secretary. He had much to do with the working of the Pilotage Act, 1913, and the greater part of his service from this date was in connection with pilotage matters. During the war of 1914-18, he was also engaged in connection with the purchase, transport and distribution of frozen meat and other refrigerated produce for the allied forces; on labour questions at the principal ports of the United Kingdom: and on the rationing of gas and electricity, rendered necessary by demands on coal. Subsequent to his retirement from Government service in 1922, he acted for twelve years as special auditor to the Mersey Docks and Harbour Board in recognition of his long and useful service at the Board of Trade. He received the C.B. in 1916.

Southampton Docks Improvement Works

Quay Widening at Berths 34, 35 and 36*

By G. W. ROOKE, B.A., B.A.I., Assoc.M.Inst.C.E.

Preliminary

THE Paper describes a work recently carried out by the Southern Railway Company at Southampton, consisting of the widening of Bertns 34, 35 and 36, which comprise tne southernmost of the berths on the River Itchen, and which have a total length of about 1,600-ft. in one continuous line.

The old quay wall was constructed of several types, but these in the main could be grouped under two headings, viz., a mass concrete retaining wall, and an open type of timber wharf of which typical cross-sections are respectively shown in Figs. 1 and 2. From time to time the wharfing shown in Fig. 2 had been subjected to strengthening works, the most important of which are shown on the section in Fig. 3.

The cross-section shown in Figs. 1 and 2 is self-explanatory, but a brief account of that shown in Fig. 3 will enable the description of the widening to be more readily understood.

The mass concrete foundation shown in Fig. 2 was, as will be seen, carried up until its higher level stood at 1-ft. above L.W.O.S.T.

At a later date the wharf was strengthened by the addition of a curtain wall running along the landward side of the high level concrete, projecting from which were built at 8-ft. intervals mass concrete piers 3-ft. wide. These were widened to 11-ft. where the bollards occurred. This new concrete embodied the piles of the original wharf, which were also at 8-ft. centres, but the deck beams, instead of being carried solely on the timber structure, were now supported by the concrete piers, with the landward crane rail running along above the top of the curtain wall.

Yet later, when the crane gauge was required to be increased from 13-ft. to 18-ft., this was accomplished by shifting the landward rail 5-ft. and carrying it on reinforced concrete beams with supporting reinforced concrete piles every 8-ft. These piles were stood on the step at the back of the concrete walls, which arrangement held for both the open type of wharf and for the mass concrete retaining wall shown in Fig. 1. To do this it was necessary to shift the rail track to landward and to cut away part of the top transverse timbering of the original quay. A dwarf wall was built along the top of the curtain wall.

At Berth 34 forward movement had from time to time taken place to a total extent of 7-ft. Stability was regained by the driving of reinforced concrete sheet piles in front of the wall and by the provision of steel ties carried well behind the adjacent passenger and cargo shed.

Such was the state of affairs before the widening.

Nature of the Ground

The geological strata at certain points along the site was ascertained by means of boreholes sunk before the work was commenced. With this information, together with that obtained during the sinking of the cylinders, it may be said that at the South end the ground consisted of a stratum of gravel about 8-ft. thick, underlying which were beds of clay and clayey sandstone. The latter was generally about 5-ft. thick, whilst below them the deeper beds of compact greensand were met.

Along the remainder of the berths the ground was found to be somewhat similar, the beds gradually rising to the elimination of the gravel. Towards the North end of Berth 35, a thick bed of greensand rises to the surface, falling later and disappearing to give the clay stratum a depth of about 30-ft. near the South end of Berth 34. Over the remainder of this berth the underlying greensand beds rise again steadily to reduce the depth of clay to a very small figure, whilst the top gravel beds reappear. Along Berth 34 there are some very thin layers of greensand and silt interspersed among the lower depths of clay before the latter finally gives way to the greensand proper.

Details of the Widening

A typical cross-section of the widening shown in Fig. 4. It was most important that the time occupied by the work should be reduced to a minimum so that the berths should not be out of use longer than was absolutely necessary, and for this reason the new construction was designed with the object of reducing side work as much as possible. Accordingly all bracings were omitted, and transverse and longitudinal stiffness provided by making the deck beams of a much heavier section than usual.

In order to guard against any likelihood of the existing walls slipping forward after the deepening had been carried out, the formation of a rubble stone bank rising from the front of the new quay to a height of about 10-ft. against the existing wall, was deemed to be necessary.

Consideration was given to the idea of carrying out the work in stages in such a way that it could be completed berth by berth, but it was obvious that such a procedure would have involved greater expense and longer time than by handing over the entire site to the contractors for the necessary period. It was, therefore, decided to commence operations at each end and to work towards the centre. All the electric quay cranes were removed from the berths and temporarily used elsewhere within the Dock Estate.

Design

The technical requirements for a satisfactory design were twofold.

Firstly, to provide a quay with decking safely able to support the maximum 40-ton corner loads from the latest 86-ft. radius 5-ton electric quay cranes, as well as all loading due to normal rail traffic and a loading on the slabs of 5-cwt. per square foot.

Secondly, to possess seaward supports to the decking of such strength as to safely resist the heaviest lateral blow from a ship coming alongside with weigh on her at L.W.O.S.T. Such a force would, according to the practice employed at the port, be transmitted to the quay through floating timber dummies 33-ft. long by 4-ft. 8-in. by 3-ft. deep.

These would be berthed one towards the bow and one towards the stern of the ship, and of such a length that they would always be in contact with at least two adjacent vertical supports of the quay, which supports would be provided with rubbing timbers.

Having decided upon a heavy decking as has already been mentioned, the design of the beams was to some extent simplified. The transverse members were designed on a section 1-ft. 10-in. (mean) by 4-ft. 3-in. deep, whilst the rail-bearing longitudinals were made 1-ft. 7-in. (mean) by 3-ft. 6-in. deep.

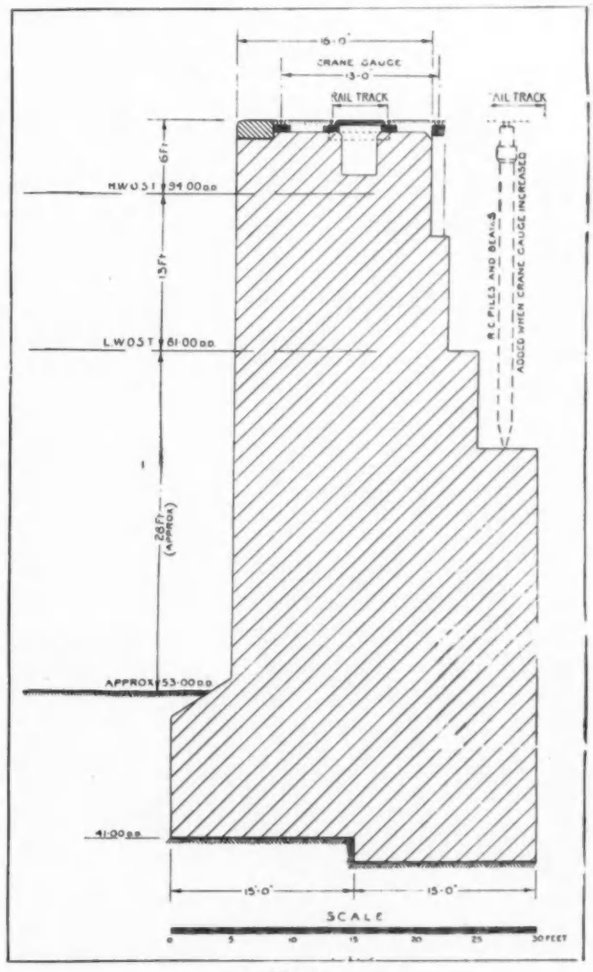


Fig. 1.

*Paper read before the Southern Association of the Institution of Civil Engineers on 25th April, 1940. Reproduced by permission

Southampton Docks Improvement Works—continued

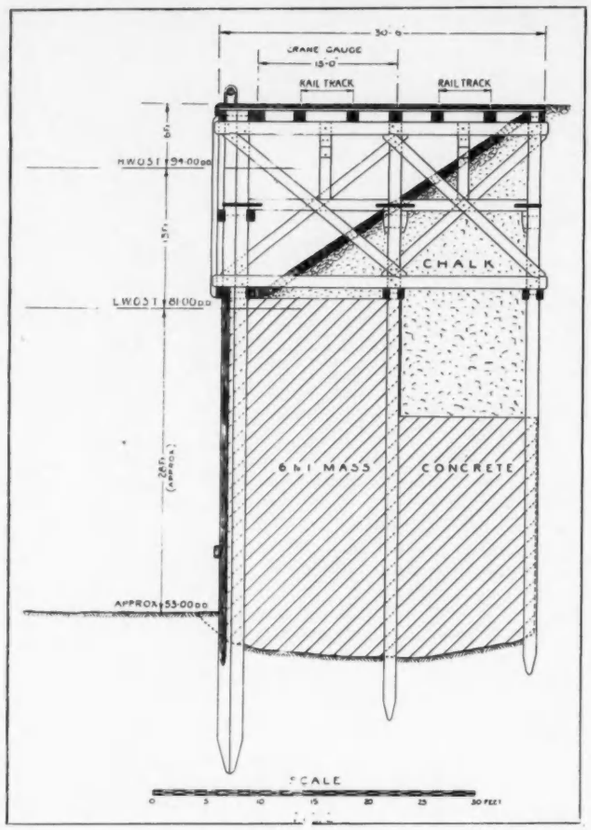


Fig. 2.

The seaward supports were designed in the form of reinforced concrete columns 7-ft. 2-in. overall diameter. These were built up of a number of cylinder sections with reinforced concrete shells 4-in. thick and 6-ft. 6-in. in height, two 15-in. by 15-in. reinforced concrete piles being driven inside and six 1½-in. diameter mild steel rods placed as reinforcement in the landward segment before the whole was hearted up with mass concrete. It is reckoned that such a support will safely withstand a lateral thrust equivalent to a force of over 50 tons weight applied at the level of L.W.O.S.T.

The intermediate supports to the decking take the form of three 16-in. by 16-in. reinforced concrete piles stripped after driving and bonded together in a pile cap over 4-ft. deep, in the top of which was formed a recess for receiving the transverse beams.

The spacing of the main frames was fixed at 16-ft. intervals generally, varied in places to meet local conditions. In order that the landward ends of the transverse beams might bear upon the front of the piers of the existing work the space between frames had to be either 8-ft., or some multiple thereof. A 32-ft. interval would have necessitated larger diameter cylindrical columns and more than three piles in the intermediate supports, whilst the floating dummies would then have had to be made 50 instead of 33-ft. long. An 8-ft. spacing would not have taken sufficient advantage of the heavy sections of the deck beams in respect of their carrying capacity.

The maximum possible loading on each of the three piles forming the intermediate supports is 50 tons, and the maximum thrust to be borne by the ground at the base of the cylinders—assisted by the piles driven through it—is 220 tons. The deadweight of the cylinder amounts to over half this total.

Two expansion joints were formed at approximately the quarter points in the length. Here the spacing between two adjacent frames has been closed up to 10-ft., and the longitudinals cantilevered off nearly 5-ft. from each. A gap of 1½-in. separates their ends, this figure being calculated on the basis of 1-in. of expansion per 100-ft. per 100° change in temperature.

For spanning the gaps between the longitudinal beams precast slabs were made in the contractors' yard. These units are 1-ft. 2-in. deep at their haunches, reducing in depth to 10-in., 9-in. and 8-in. respectively, according to their spans. Where they have to support the rail track cross-overs their thickness has been maintained at 14-in. thickness throughout. The largest of these units weigh nearly 9 tons, but in spite of this it was considered that much time would be saved in forming the decking in this manner.

The average deadweight of the decking works out at 3¼ cwt. per sq. ft.

The sizes of the reinforcement was standardised as far as possible, 1⅛-in. diameter and 1-in. diameter rods being used for the beams, with ⅜-in. diameter and 5/16-in. diameter stirruping, whilst the rod sizes in the pre-cast slabs vary from ⅜-in. down to 5/16-in.

The transverse beams were designed as continuous over the intermediate supports, with part fixity at the cylinders and simple support at the landward bearing. The longitudinals were considered as continuous over an infinite number of spans.

Cast steel bollards were placed at 48-ft. intervals towards the ends of each berth, the spacing being increased to 64-ft. elsewhere. They are anchored with 2-in. diameter mild steel tie rods taken well back into the heart of the transverse beams, as well as four 1¾-in. diameter anchor rods extending down into the cylinders.

The layout of the new deck covering the existing walls—the original surfacing, bearers, etc., having been completely demolished—varies according to the nature of the underlying construction.

In the sectors formed in the open type of wharf 9-in. pre-cast reinforced concrete slabs have been laid spanning from pier to pier, excepting where the rail track cross-overs are encountered. Here a 15-in. cast-in-situ reinforced concrete slab has been formed with its top surface set 5-in. lower than finished level, in order to receive the flat bottom rails. The existing mass concrete piers intermediate between main frames were built up to the same level as the reinforced concrete ties at the main frames, in order to provide a support for this arrangement of slabs.

A duct consisting of an opening in the existing piers 2-ft. 6-in. wide by 3-ft. deep with a 3-ft. wide timber platform spanning across the gaps has been constructed, the purpose being to house and give access to the electric mains feeding the cables running along the front of the new quay. This arrangement involved a great amount of concrete demolition and other work, and had a marked effect on the manner in which the contract had to be organised.

In the mass wall sectors a duct of similar size already existed, the cables being reached by lifting up the loose timber covers which then formed part of the decking. These latter were dispensed with, all existing longitudinal timbers were removed, the tops of the duct walls trimmed down where necessary and a 10-in. cast-in-situ reinforced concrete slab reinforced with ½-in. diameter and ⅜-in. diameter rods was laid. Underneath the rail track cross-overs the slab was dropped 5-in., and the spacing of the main rods decreased.

In the latter sectors the standard reinforced concrete ties to the transverse beams, which in the case of the open type of wharfing were taken across the tops of the existing piers and returned down the back of them for the purpose of tying the

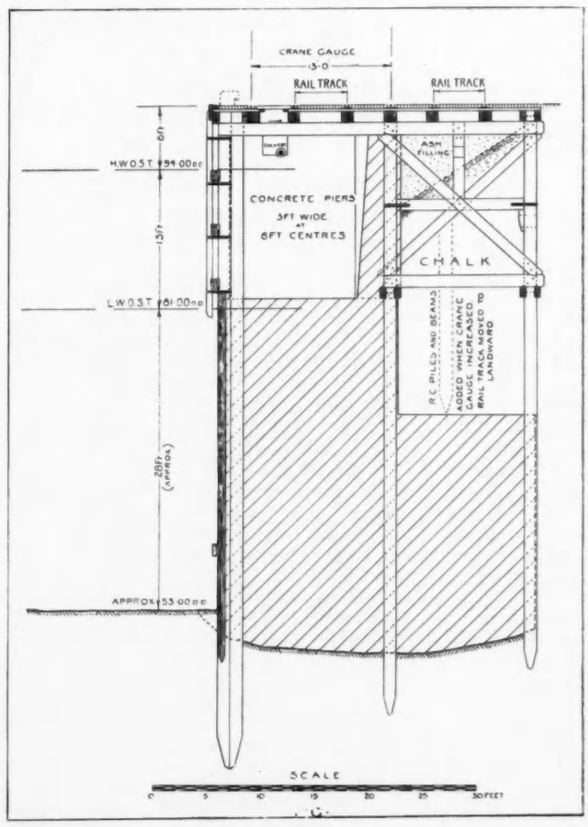


Fig. 3.

Southampton Docks Improvement Works—continued

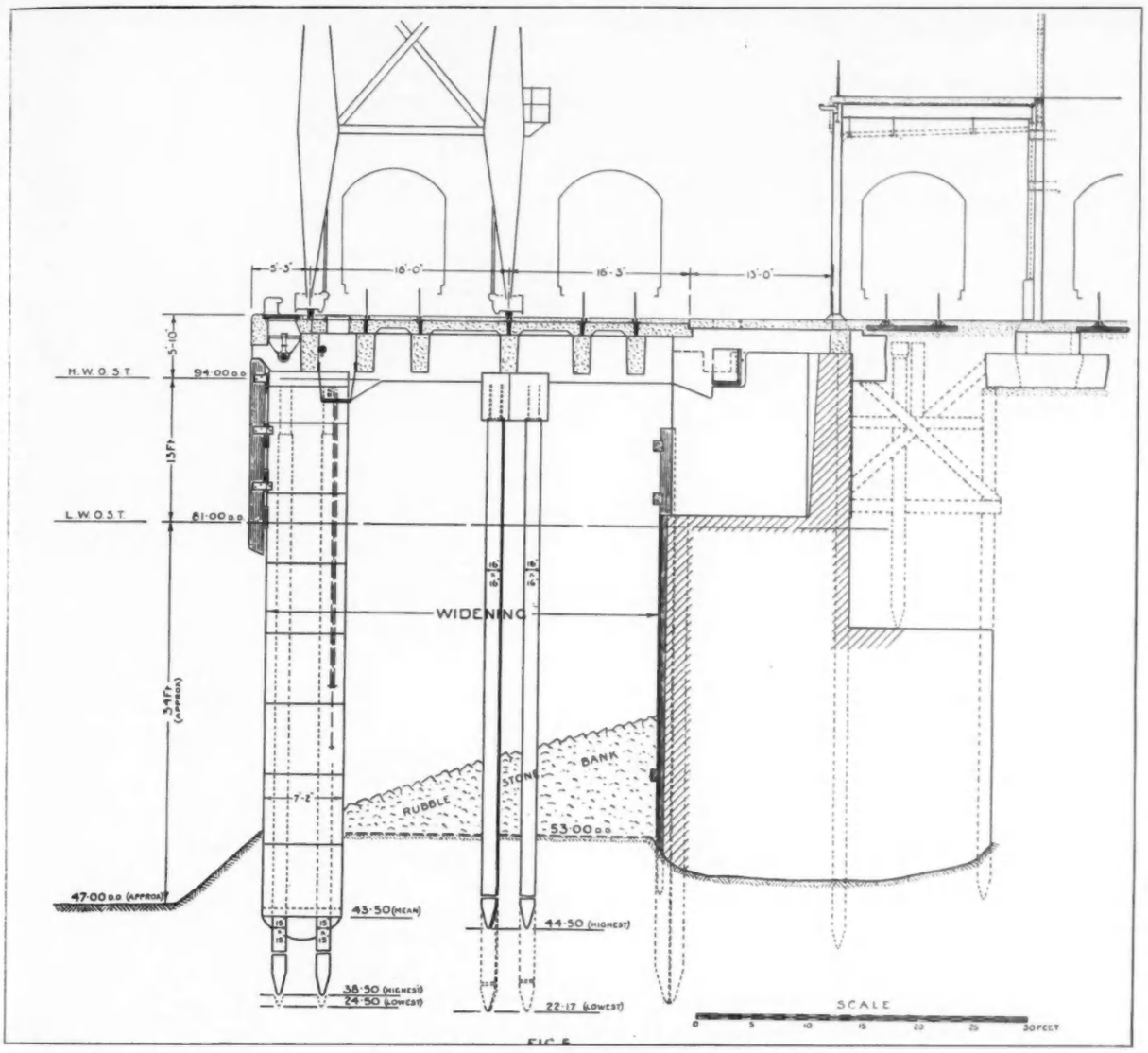


Fig. 4.

new work to the old, were dispensed with. In their place channels 2-ft. 6-in. wide by 6-ft. deep were cut through the existing wall as far as the seaward side of the duct. Into these were carried the main reinforcement to the transverse beams, and the whole refilled with concrete simultaneously with the casting of the deck beams themselves.

Loading Platform

To facilitate the loading of cargo on the first floor of Sheds 35 and 36 a loading platform 19-ft. wide was designed to replace the narrow 5-ft. landing then existing.

The new platform is carried on stanchions at 20-ft. centres with main longitudinal members, secondary beams being placed transversely at 6-ft. 8-in. centres. The landward stanchions are strapped by batten plates to the seaward stanchions of the existing sheds. The foundation blocks underneath these had to be enlarged somewhat in order to maintain the ground pressure at a safe figure. This was done by cutting downwards to taper the sides of the lower portions of the blocks and adding all around an additional width of concrete, the latter being reinforced with hoops in order to guard against any bursting tendency. Shuttering was not used in this operation, it being cheaper and more convenient to refill the entire excavation with concrete.

The upper portions of the blocks were similarly treated, but here no tapering of the existing concrete was necessary. Shuttering was used in this instance, being obviously the correct procedure under the circumstances.

The reinforced concrete deck slab is 7-in. thick at the landward side, falling by 1-in. to seaward, reinforced with B.R.C. No. 5 fabric and designed as a continuous slab over an infinite number of spans. Chains and stanchions were placed along the seaward side, returning at the ends to the existing sheds.

Sequence of Operations

Considering any one particular point along the quay, the order of carrying out the various items of construction was as follows:—

(1) Driving intermediate piles, followed closely by placing sinking and piling cylinders and placing reinforcement in same, and hearting up to the level of approximately 1-ft. 6-in. above L.W.O.S.T.
(2) Stripping intermediate and cylinder piles; extending the former where necessary and casting pile caps; fixing fender bracket and bollard anchorages and completing cylinder hearting.
(3) Demolishing the decking of the existing construction; cutting out for landward bearing of transverse beams and for duct formation; excavating around shed stanchion bases and cutting away sides to taper.
(4) Setting shutters and reinforcement to deck beams, reinforced concrete ties and intermediate piers and casting same.
(5) Forming bases and catch pits under front supports to loading platform, and casting additional portion to shed stanchion bases.
(6) Casting out stone through gaps between deck beams to form a rubble bank underneath.
(7) Placing and jointing asbestos cable conduits, and fixing and hanging timber platform underneath plug boxes and manholes.
(8) Placing and hanging water main.
(9) Setting shutters and reinforcement to cope beam and slab, and casting same.
(10) Placing and bedding pre-cast slabs on deck beams.
(11) Erection of steelwork to loading platform.
(12) Fixing timber platform in duct at back of widening.
(13) Formation of in situ and placing and bedding pre-cast slabs above existing construction.

Southampton Docks Improvement Works—continued

(14) Casting slab to loading platform, followed by fixing gutters and rain-water downpipes.
(15) Cutting, shaping and fixing fender packings and fenders, packings being site measured in every case.
(16) Fixing ladders and life chains and steps at south of quay.

Cylinder Building and Sinking

The cylinders, as has already been stated, are formed of sections of 6-ft. 6-in. internal diameter by 6-ft. 6-in. high, with shells 4-in. thick cast with 3½ to 1 concrete and reinforced with B.R.C. fabric made up of No. 4 gauge wire. This was added mainly for handling purposes.

Circular steel moulds were used, vibration and punning being done respectively by electric vibrators fixed to the outside of the moulds, together with vertical tamping by means of hand-operated rods with small flat blades at their ends.

The bottom sections were fitted with sheet steel cutting edges 9-in. in depth, in order to assist sinkage.

The output reached a maximum figure of 60 in one week. The minimum period after casting at which the sections were permitted to be dispatched on the site was 14 days. "Ferrocrete" Rapid Hardening Cement was used throughout their manufacture.

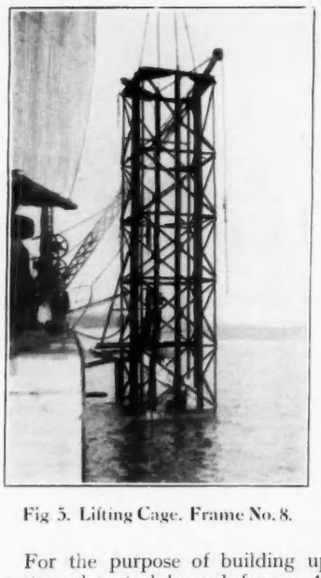


Fig 5. Lifting Cage. Frame No. 8.

One complete cylinder comprised a bottom unit with cutting edge, six standard-depth sections and one shallow top section 1-ft. 4-in. depth, with its thickness increased at its seaward segment to form a flat face parallel to line of cope. The main contractor formed yet another length of variable depth known as the "making-up" section, cast inside circular steel shutters clamped around the topmost standard section. This was concreted simultaneously with the upper portion of the hearting, for which a 3½ to 1 mix was used. The inclusion of such a section avoided a difficulty which would otherwise have arisen, as it was not found practicable to sink all the cylinders to exactly the same level.

For the purpose of building up the cylinders, a number of rectangular steel braced frames 45-ft. deep were used. Fixed internally in the centre of each side ran vertical guides in the form of R.S.J.'s, with the distance between the inner flanges of each opposite pair such as to give slight clearance per side when the sections were being lowered. The frames were lifted and lowered into position by derrick illustrated herewith (fig. 5), the bottom being held in the river bed, and the top strutted off the quay from its two landward corners by means of two variable-length tubular members, and tied by wires running diagonally across from all four corners to the existing quay.

After a band of mastic of about ½-in. diameter had been placed around the base of each spigot the units were lifted and dropped one by one into position. This operation is illustrated in the photograph (fig. 6).

The seven sections having been placed and sunk as presently described, a couple of whole timbers were laid across the top of the cylinder frame, and the pile frame super-imposed for driving the two internal piles. These driven, and the 1½-in. diameter reinforcing rods hung in position, the pile frame was removed and the cylinder filled with 6 to 1 mass concrete made with ordinary Portland cement, up to a level about 1-ft. 6-in. above L.W.O.S.T.

The concrete was placed in the wet by means of a deep box with bottom-opening doors, dropped down between the piles and suspended in such a manner that the doors could not be opened unless the derrick applied its lift with the skip sitting on the already-placed hearting. There were thus no danger of the concrete being deposited so that it would have to fall several feet through water and thus lose a large proportion of its cement. After this filling had hardened the cylinder frame was removed, and later the piles stripped to the specified depth from their tops —viz., 4-ft. 6-in.

At first much difficulty was experienced as to the best way of tackling the work of placing fender bracket fixings. The cutting of the holes for the lower cast iron sockets could only be done at very short intervals of low water on a spring tide, and if the work were confined to such periods the whole programme for carrying out the contract would have been jeopardised.

By a slight adjustment in the length of the standard cylinder sections and by raising the levels of the lower and middle fixings, it was found that both sets were brought within the limits of the topmost, i.e., seventh, standard section. It was therefore agreed to follow up the 6 to 1 hearting operation by taking these sections ashore again, there cutting the holes and casting the entire anchorages in position, to template. As soon as the mortar had hardened the sections were replaced on the cylinders and the hearting, together with the formation of the making-up section, continued upwards.

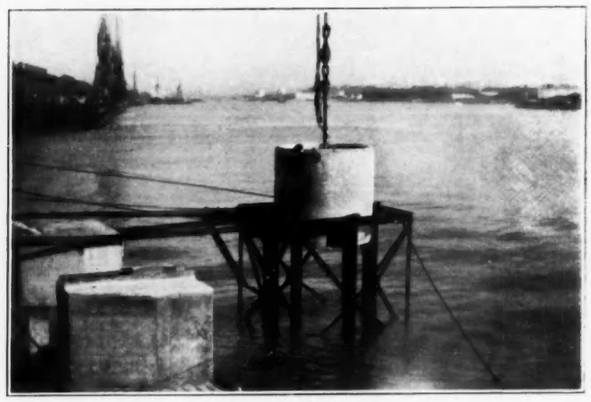


Fig. 6. Setting Cylinder.

The last operation was the placing and hearting of the shallow top section containing the upper fender bracket fixings.

Along the greater part of Berth 36, where the top stratum was gravel, sinking proved an easy matter, being carried out by grabbing only. The time taken averaged half a shift, although one case is recorded where this time was as little as two hours.

Over the remainder of the widening—both in the greensand along the North end of Berth 35 and in the clay along Berth 34—the majority of cylinders took about 1½ shifts to sink. Not only grabbing, but also the employment of kentledge weights and the scarifier were necessary. Of the total sinkage of about 7-ft. 6-in. the first 3-ft. 6-in. could generally be accomplished by grabbing, but after that the application of about 23 tons of kentledge placed on whole timbers lying across the top of the cylinder was necessary. With the alternate use of the grab and the weights, which would usually be taken off and replaced two or three times, the cylinder would be finally sunk to its level. In the more obstinate cases a scarifier was used as well. This was made of a number of steel joists fabricated as a cruciform, with the outside joists cut to taper at their ends, and twin angles rivetted to each. This was lifted up by the derrick, placed down in the cylinder and dropped several times into the excavation in order to try and chisel the material away from the cutting edges. The operation, involving removing all five kentledges, weights and supporting timbers, hitching on scarcifier and then

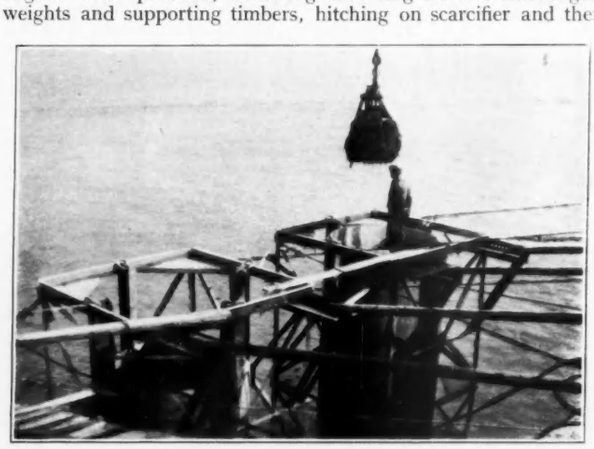


Fig. 7. Sinking Cylinder by Grab Dredging.

lifting up and down, followed by the resumption of grabbing and then of reapplication of the weights, was a slow and costly business and was only carried out in the most difficult cases. It did not meet with much success in the tough clay along Berth 34. The operation of sinking by grabbing is shown in the photograph (fig. 7).

With one exception where the strata encountered was exceptionally tough greensand, all cylinders were sunk to level. In the case referred to although excavation was carried out to a depth of 5-ft. below the cutting edge—a figure 3-ft. in excess of that usually allowed—no further sinkage beyond 1-ft. 3-in. above the required level could be obtained. Ballast refilling was

Southampton Docks Improvement Works—continued

then cast into the 5-ft. depth before driving the piles. Boulders in greensand were met with and removed in a few cases, and in seven instances obstructions such as wire ropes, pieces of timber, etc., had to be grabbed up before any sinking could be done. On the whole, however, the operation was, if very slow at times, not unduly difficult, and was carried out in 105 out of 106 cases with complete success.

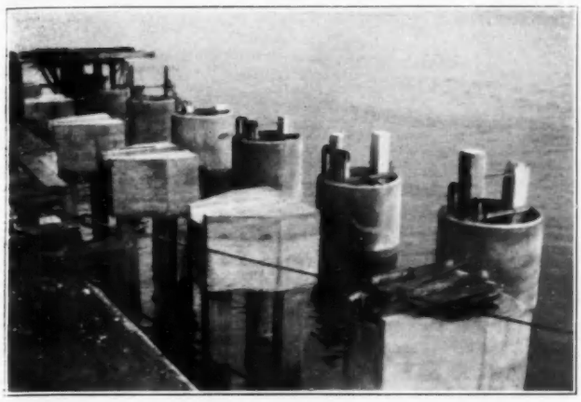


Fig. 8. Cylinders partly complete with intermediate piles.

The method of driving the intermediate piles was similar to that employed in driving those inside the cylinders. The same steel frames were used, with the pile frame super-imposed.

A photograph (fig. 8) shows the cylinders partly complete, and intermediate piles bonded together in caps.

Piles and Pile Driving.

Cylinder piles are of 15-in. by 15-ft. section, reinforced with four $1\frac{3}{8}$-in. diameter ins. rods with $1\frac{1}{2}$ cover and $\frac{1}{4}$-in. diameter stirrups at 3-in. and 6-in. centres.

Intermediate piles are 16-in. by 16-in. section similarly reinforced, but with 2-in. cover over main rods.

The lengths were in the first instance fixed at 55-ft. for the intermediates and 58-ft. for those in the cylinders. Whilst these were generally sufficient along Berth 36, they were far too short at the opposite end of the site, where the clay stratum extends almost from the surface down to a considerable depth, reaching a maximum of 30-ft. before the greensand is met with. The length was therefore increased to 60-ft. in both cases, and to 67-ft. in the later batches cast as a result of information obtained by driving a test pile at the North end of Berth 35. In the latter region the driving was very hard through the top layer of greensand and silt, becoming much easier through the clay beneath and finally pulling up to set in the succeeding beds of greensand.

More than sixty of the shorter-length intermediate piles at Berth 34 had to be extended, in all cases in situ after driving had been completed. Where those lengths were only slightly too short on Berth 36, the soffite of the pile cap was lowered, avoiding individual extensions and thus saving much time. Twelve caps were deepened for this reason.

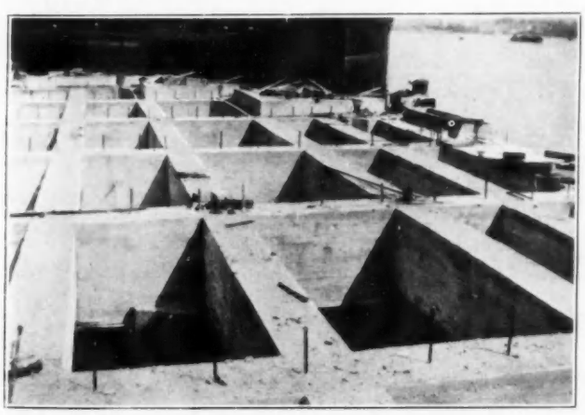


Fig. 9. Transverse and Longitudinal Beams.

Generally speaking, the driving did not present much difficulty, although in the case of about fifty intermediate piles, cracks, a number of which were visible right around the piles, were found after driving. The specified set was $\frac{1}{2}$-in. to 10 blows from a 3-ton hammer falling 3-ft. This was certainly severe on the piles and in some cases necessitated as much as from 30 to 40 minutes continuous and hard driving. Criticism might be levelled at the insistence of so heavy a set. It will, however, be remembered that the intermediate piles are liable to be loaded up to the considerable figure of 50 tons. What is more, with the thin layers of firm material which were in places interspersed in the clay, there was always the possibility of driving almost through these beds and getting a false set. One such instance was in principle recorded, a pile taking a set of 1-in. to 10 blows and then going away easier for another 5-ft. before taking the required set.

In some piles the cracks were probably due in part to the fact that there was a long unsupported length between the head receiving the blow and the point of fixity beneath the surface of the ground—a matter of about 50-ft.

A V-shaped chase about $\frac{1}{2}$-in. deep was cut in piles whenever cracks were visible, and then sprayed with mortar by the cement gun process, thus effectually forming a seal against any rusting of the reinforcement.

The greatest penetration attained by the intermediate piles was nearly 31-ft., whilst the least was 8-ft. 6-in., the minimum permissible depth. Similar figures for the cylinder piles were 19-ft. and 5-ft. respectively.

Except for a 250-ft. length opposite the gap between sheds 34 and 35 the intermediate piles drove reasonably true to position. Over this stretch, however, many of them kicked rather badly, and it was among these piles that the worst cracks occurred.

Deck Beam Construction

The shutters for the deck beam casting were timber, with steel girder supports. Two 16-ft. bays, i.e., a complete bay plus two halves, were usually taken at one casting. The amount of concrete required was considerable, about 75 cu. yds. of aggregate being necessary for a 32-ft. length of decking exclusive of the pre-cast slabs.

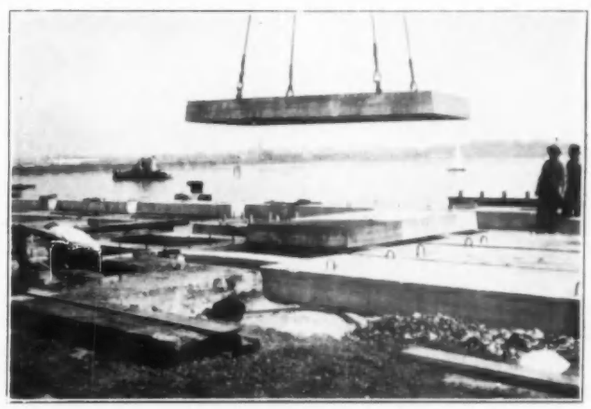


Fig. 10. Setting of Pre-Cast Slabs.

Satisfactory progress was maintained by starting at each end almost simultaneously and working towards a junction point near the north end of Berth 35. Concreting had to be commenced as soon as the formwork and reinforcement had been passed as satisfactory, and this meant that a fair proportion of the casting had to be undertaken during the hours of darkness. The difficulty encountered in carrying out such work, especially in view of the complexity of the shuttering, under conditions other than in daylight is shown by the fact that the time taken by the day shift was six hours on an average, whilst the night shift generally required 50 per cent. longer.

The concrete was taken up in layers of 9-in. throughout, and an effort was always made to get back on top of the preceding layer within an hour. This was usually accomplished during the day shift, but not so at night. It was, however, considered that this time was not sufficiently exceeded to be in any way harmful.

"Ferrocrete" Rapid Hardening Cement was used for all reinforced concrete work, and soffite shutters were allowed to be removed after three days in warm weather, provided that the concrete was kept thoroughly wet throughout that period, and well watered for the remainder of the first week after casting.

A general view of some of the transverse and longitudinal beams will be seen in the photograph (fig. 9).

Vibration was applied to all reinforced concrete throughout the job, the immersion type being used. Several such instruments were employed on the contract, and they proved most efficient, enabling a dry mix to be used without any resultant honey-combing. It was most surprising to see how quickly they could convert a heap of stiff concrete into a fluid mass. Washed and graded aggregate was used—graded so as to give a mix of maximum density—in the proportion of $3\frac{1}{2}$ parts to 1 part of cement.

Southampton Docks Extension Works—continued

Formation of Rubble Bank

Following the deck beam casting came the operation of forming the rubble bank. The trucks loaded with stone from the quarries were shunted on to the site, transferred into skips and unloaded through the gaps between the deck beams. The requisite formation was ensured by taking soundings.

Fig. 11. Crane and Rail Tracks.

Laying of Pre-Cast Slabs

This operation presented no problem of particular interest, the units being bedded in 3 to 1 mortar. The laying of one of the medium-sized units is shown in the photograph (fig. 10).

No other item calls for any comment except—

Fender Fixing

The 15-in. by 15-in. Greenheart timbers about 19-ft. long had to be fixed by two bolts, each to three pairs of cast-iron fender brackets. As, however, the cylinders varied a little in their positions relative to the cope face with which the fenders were required to be lineable, each timber had to be slung over the side by crane and temporarily clamped in position. Offsets were then taken for each of the four Greenheart packings. The latter having been previously shaped, were then cut to the required thickness and spiked on to the back of the main timber ashore and the whole replaced, bored and bolted to the fender brackets.

Other Works

The laying of the crane and rail tracks and the completion of the concrete quay surfacing was carried out by the Southern Railway Company under administration. Fig. 11 shows the completed quay with loading platform looking northwards from the southernmost frame. Fig. 12 shows Berths 36 and 35 as widened, viewed from the River Itchen.

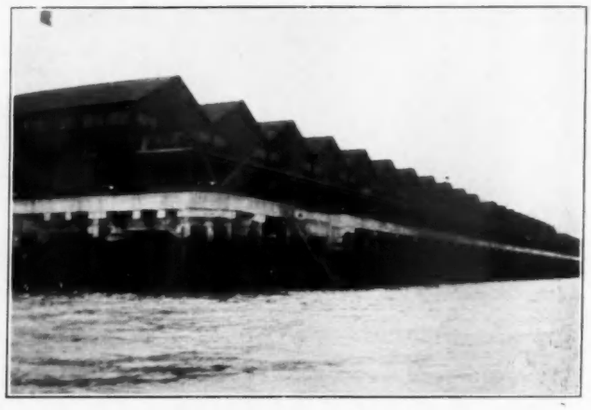


Fig. 12. View of Completed Quay Widening.

The work was designed and carried out under the direction of Mr. M. J. G. McHaffie, M.Inst.C.E., Docks Engineer, Southern Railway. The author prepared the working drawings and was Resident Engineer on the works. The contractors for the construction of the widening were Sir Robert McAlpine and Sons (London), Ltd., who were represented on the site by Mr. J. Hardie.

The contractors for the dredging of the berths were the James Dredging, Towage and Transport Company, Ltd., who were represented on the site by Mr. G. H. James and Mr. G. H. A. Pursey.

British Port Data

Admiralty Prohibition of Publication

During the past month the following veto on the publication of tidal, hydrographical, and information generally, relative to conditions at British ports, has been issued by the Admiralty:—

(1) The publication of detailed data concerning British ports is prohibited under Regulation 3 of the Defence (General) Regulations, 1939.

(2) This Regulation forbids *inter alia* the obtaining, recording, publishing or communicating of any matter whatsoever, information as to which would or might be directly or indirectly useful to an enemy, and likewise forbids any person to have in his possession any document containing any such information, unless in either case authority or permission has been given by or on behalf of His Majesty. Tidal predictions, hydrographic and other port information are useful to an enemy.

(3) All persons are informed that, in accordance with this Regulation, it is prohibited, save with written authority first obtained from the Hydrographer of the Navy or a duly appointed official acting on his behalf, to publish any tidal predictions, hydrographic information or other port information falling within the meaning of paragraph 2 above and heretofore published in part or in whole in the public Press, and also normally included in books and pamphlets issued in respect of facilities obtaining at British ports.

(4) It is further notified that the written authority above referred to is granted only in cases where the publication is subject to Admiralty control so far as the distribution and/or sale thereof is concerned.

(5) Particulars of the scheme of control may be obtained on application to the Hydrographic Department (Sales Branch).

Lambert-Garland Mooring Buoy.

We are informed by Messrs. Wm. McNeill and Co., Ltd., of 125, West Regent Street, Glasgow, that they have been appointed Agents in Britain for this buoy, a description of which was given in the issue of February, 1940.

Correspondence

To the Editor of "The Dock and Harbour Authority"

The Port of Maracaibo

Sir,—

My attention has been called to an "Editorial Comment" in your issue of September, 1940, entitled, "The Port of Maracaibo and its Approach Channel," which might give the misleading impression that the United States of America or the Corps of Engineers, U.S. Army, were in some way responsible for this work.

The work in question is being done at the expense of certain oil companies under the supervision of the Republic of Venezuela. Several years ago, at the request of the Government of Venezuela, model studies of this project were made at the Waterways Experiment Station maintained by the Corps of Engineers at Vicksburg, Mississippi. The United States was reimbursed for all expenses incurred in making this study. Some retired officers of the Corps of Engineers have acted, entirely in a personal and unofficial capacity, as consulting engineers on this and related projects.

Except as above stated the Corps of Engineers has no connection with this project, nor with other harbour movements in South America, and has no responsibility for the design, construction or operation of such projects.

Respectfully yours,
THOMAS M. ROBINS,
Brigadier-General,
Assistant to the Chief of Engineers.

War Department,
Office of the Chief of Engineers,
Washington.
October 11th, 1940.

[We regret the misleading nature of the statement in the comment, which was based on the information contained in a press report.—Editor].

Tyne Improvement Commission.

At the annual meeting of the Tyne Improvement Commission in November, Sir Arthur M. Sutherland was re-elected Chairman, and Colonel Sir Frank Simpson, Vice-Chairman.

To Correspondents

All Letters and Contributions intended for Publication should be addressed to the Editor of "THE DOCK AND HARBOUR AUTHORITY," 19, Harcourt Street, London, W.1, and must in all cases be accompanied by the name and address of the sender.

The Editor cannot be responsible for the safety of or return of manuscripts forwarded on approval.

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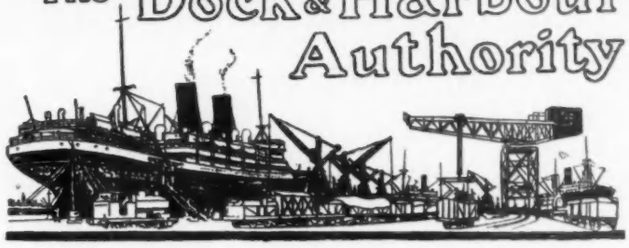

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Fig. 1

Fig. 2

The foreshore was dredged as shown in Fig. 1, and the dredgings barged to a floating pump station (Fig. 2), which pumped out the dredgings and forced the material through a 24-in. pipe laid alongside the railway line, under which it passed as shown in Figs. 3 and 4.

The material which consisted of sand, mud, clay and ballast, was finally discharged into a water area (Fig. 5) which has been reclaimed for extension purposes. The total length of the discharge pipe was about half-a-mile.

Fig. 3

Fig. 4

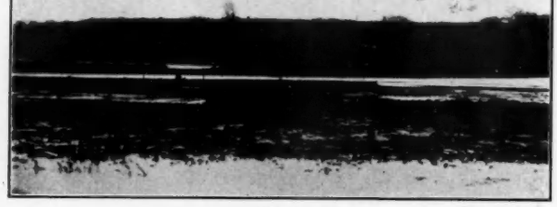

Fig. 5

All enquiries to Head Office

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" (Foreign):—Soundings London.

Telephone:—Bishopsgate 7266 (2 lines).
Codes:—A.B.C. 5th Edition Bentleys.

*Navigational Fog Signals**

By J. W. TONKIN, M.Inst.C.E.I.

(Concluded from page 16)

Sound Generator

We come next to the actual sound generator, and here a veritable jungle of variables renders the design of a satisfactory siren a matter of the greatest difficulty.

We require to produce in the throat of a trumpet the greatest possible alternation of pressure without turbulence, or eddies, at a frequency already decided on. To do this, it is clear that for a given area of throat there is an economical limit to the quantity of air under pressure that can be used, and this with a fixed air pressure is determined by the area of the ports, and by the time they are open admitting air to the throat.

For a pressure of 30 lbs. per square inch the ratio of port area to throat area, are found by experiment, should be about $\frac{1}{3}$; if anything, rather less, than rather more.

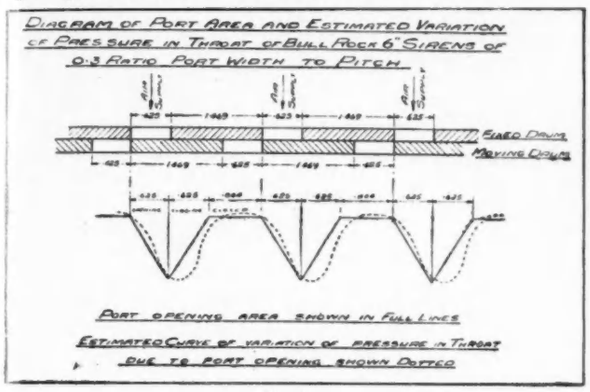


DIAGRAM OF PORT AREA AND ESTIMATED VARIATION OF PRESSURE IN THROAT OF BULL ROCK 6" SIRENS OF 0·3 RATIO PORT WIDTH TO PITCH
FIXED DRUM
MOVING DRUM
PORT OPENING AREA SHOWN IN FULL LINES
ESTIMATED CURVE OF VARIATION OF PRESSURE IN THROAT DUE TO PORT OPENING SHOWN DOTTED

Fig. 6.

As a result of the tests made at St. Catherine's Point, it was concluded that a pressure of 25 lbs. per square inch was the most suitable pressure, and it has been stated since, that various pressures between this and 30 lbs. per square inch, are the most efficient. Port area and pressure are however inter-dependent and experiments appear to show that when the ratio $\frac{\text{Port area}}{\text{Throat area}}$ is appreciably less than $\frac{1}{3}$, it is advantageous to raise the pressure, and vice versa

It is quite possible however that the output of an instrument of a given diameter could be more economically increased by exhaustion of air from the throat between successive port openings, than by increasing the pressure to over two atmospheres, as there appears to be, even when the port area is taken into account, some limiting factor about the pressure, in the region of two atmospheres.

So far as is known, no experiments have been made to obtain information on this.

The ratio of port width to pitch (the latter term being the distance between the centres of the ports measured circumferentially on the outside of the revolving drum), determines the proportionate time they are open.

Various ratios between wide limits have been adopted from time to time, but no conclusive results have, so far as is known, been obtained from experiments, nor has any mathematical investigation apparently been published.

At the London 1929 Conference previously referred to, it was stated (p. 61 of the Report) that a ratio of 1 to 4 was best, as this gave a sine curve of pressure; in another place (p. 63) it is stated that a ratio of 1 to 1 was adopted by a General Lighthouse Authority.

Now this latter ratio could hardly be expected to be at all satisfactory, for, as pointed out at the Conference, the ports would be virtually open throughout the blast.

The 1 to 4 ratio does not appear to be correct either, if the ports in the rotating drum, and in the fixed drum, are of the same width, as they usually are.

Siren ports are normally plain oblong slits, or (and this is probably better), slits with semi-circular ends, the width being transverse to the axis of rotation.

It is exceedingly doubtful whether any ratio of width, to distance apart, would give a sine curve of pressure, or any symmetrical curve.

When the ports are opening air enters at maximum pressure into what is virtually a cylinder, closed at one end, and open at the other. The port area is sufficient to cause the pressure in the cylinder to build up, setting up an increasing back pressure until *after* the port is fully open. At that time the air inlet pressure is at a minimum, and the back pressure at a maximum. Now with the port closing, there would be a relatively steeply falling curve of pressure in the throat of the trumpet, because this is open to the atmosphere, and because the compressed air in the throat is in motion away from the stopped end.

Apart from this, with ports fully open, only instantaneously, they may be considered to be open, from the position at which they are half open, to the position at which they are half shut, and this being so, the ratio of 1 to 4 means that the ports are virtually open for this fraction of the cycle only, and closed for $\frac{3}{4}$ of the cycle.

In the sirens at Bull Rock the ratio of 0.3 was chosen as being nearly $\frac{1}{3}$, with the error, if any, on the safe side, as the ports can, of course, only leak air when they are closed, and any leakage past the ports there may be, would be greatest immediately before opening and after closing and this would tend to build up the pressure curve.

The diagram, Fig. 6, shows a partial development of the two drums, and an indication of the pressure conditions in the throat of a siren where the ratio of the width of ports to distance apart is 0.3.

The number of ports adopted for Bull Rock was 9. This was for no particular reason, except that a siren with this number was previously tested by the writer for air consumption, and the choice reduced the variables by one. An even number is to be preferred however, and 8 ports would be rather better on the whole, although the difference is quite unimportant.

The 8 port siren would of course require to be driven 9 8 times faster than the Bull Sirens to give the same note.

A " G " size diaphone (Fig. 2) and a 6-in. siren (Fig. 1) are instruments of a comparable size, and it is of interest to examine the differences in their details which are set out in the table below:—

	Diaphone	Bull Rock Siren
1. Area of throat	27·9 sq. in.	23·76 sq. in.
2. Area of slits/ports	10·635 "	7·38 "
3. Ratio of port area to throat area	0·38	0·31
4. Number of slits/ports ...	10	9
5. Width of slits/ports ...	0·06"	0·625"
6. Length of slits/ports ...	17·725"	1·3125"
7. Length of stroke	0·33"	—
8. Duration of port opening in secs. for a distance of 2 × width of port for 128 vibrations per sec.	0·0017 sec.	0·0046 sec.
9. Ratio of width of slit, to stroke, or to pitch ...	0·182	0·3
10. Air consumption per second of blast	23 cub. ft.	27 cub. ft.

It can be seen that there is a considerable disparity in the respective widths of the slits in the diaphone, and the ports in the siren, also in the duration of port opening in each case. The loudness of the diaphone is apparently mainly due to shock effect set up in the throat, while the siren has what has been described (by Devik & Dahl " Acoustical Output of Air Sound Senders ") as a more co-ordinated air flow which perhaps tends towards producing a progressive sound wave.

The form of sound wave given by a diaphone, and shown in Fig. 2 is taken from the paper just mentioned.

The Norwegian writers state that they consider it astonishing that the contribution to sound radiation of the pressure impulses does not exceed to a much greater degree the membrane action of the piston. They must have been guided by faulty instrumental readings, as aural observations do not confirm this view. At a distance of about half-a-mile, the membrane action of the piston produces a low purring sound of no great power, and when the air is turned on there is in the writer's opinion a vast improvement in intensity, and of course, to the ear, the characteristic ragged, disagreeable sound associated with the diaphone.

The " Grunt " in a diaphone note, first investigated and explained by the writer in 1918, is due to the slowing down of the piston frequency, past a point which corresponds to the fundamental note of the trumpet, i.e., the lowest note it will, as a resonator, respond to.

In Devik & Dahl's excellent article, mainly on electric horns, they mention that they found it impossible to record the " grunt," so what they show must be from a higher note, and some of the kinks in the sound wave, as recorded, appear to be due to the half " smothered " influence of the trumpet.

In the duration of the port opening given for the diaphone on p. 100 it is assumed that the piston is uniformly accelerated from rest, to mid-stroke, when its maximum velocity for 128 vibrations per second is about 7-ft. per second, which is of course only about 1/160 of the speed of a sound wave in air. But it is not unlikely that the actual motion of the piston when the record was made was not one of uniform acceleration, and this of itself would introduce complications. Assuming that the sound wave produced by a diaphone is of the type illustrated, there appear to

*A Paper read before the Institution of Civil Engineers of Ireland on March 4th, 1940, and reproduced by permission.

Navigational Fog Signals—continued

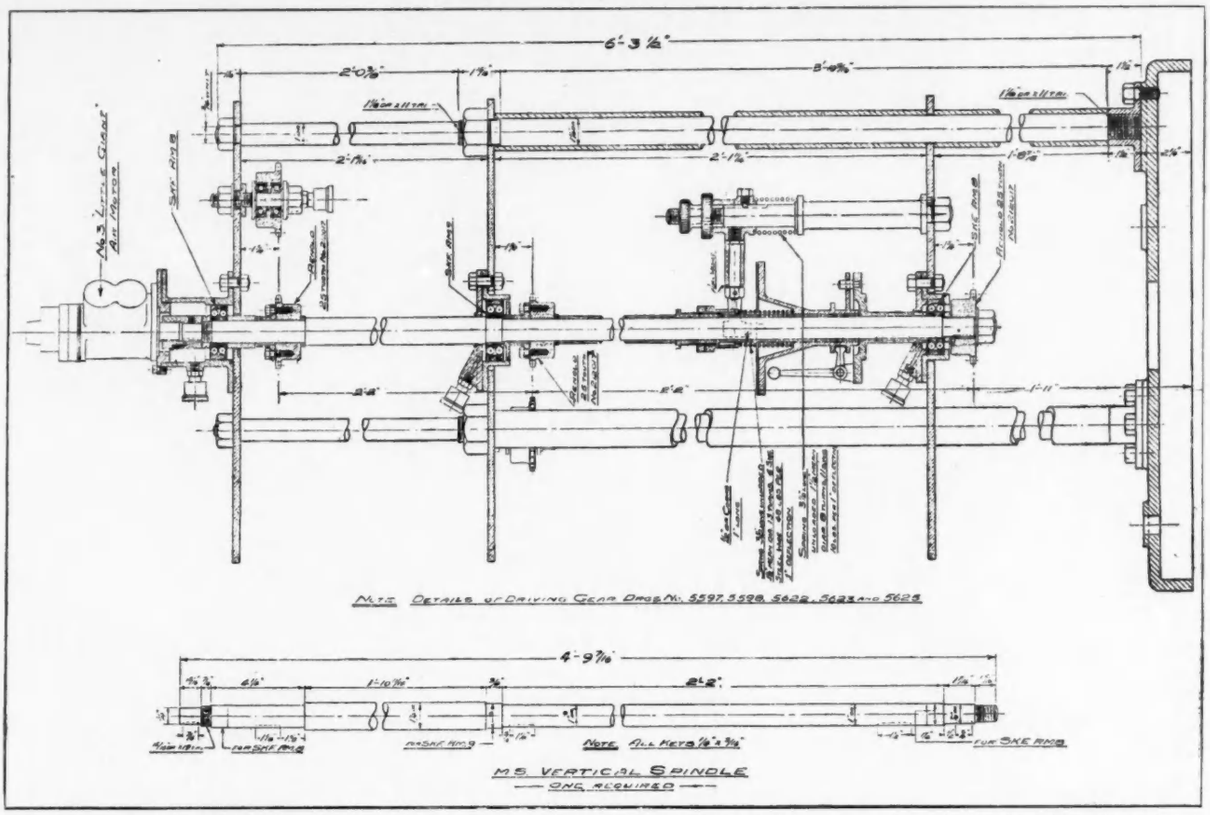


Fig. 7. Bull Rock Lighthouse. Arrangement of vertical shaft with sprockets for 375-in. pitch chain drive to three 6-in. diam. Sirens

be good grounds for believing that a very considerable improvement in the acoustic efficiency of the instrument is possible.

The motor effect on a running siren when the sounding air is turned on is very considerable. It will tend to accelerate in whichever direction it happens to be running.

Consider Fig. 6 and say the port to the left which we can suppose to be slightly open. Air from above (outside the fixed drum) blowing down between the edge of the fixed port, and the leading edge of the revolving port will tend to widen the gap, and this will continue until the port is fully open. But by this time the pressure from below (inside the revolving drum) will have reached a considerable fraction of the inlet pressure, so the conditions as far as motoring is concerned for the second half of the port opening are different to those of the first, i.e., the retarding effect of this half of the travel is relatively small, and consequently the siren, when sounding, will tend to accelerate in whichever direction it happens to be started.

If vanes are fitted as shown in Fig. 1 they will slow down the siren when the air is turned on, unless sufficient clearance is left, air (relatively viscous in comparison with its density) is rendered still more viscous when the pressure rises. It is a simple matter however to make the vanes nullify the motor effect, and speed control is thus rendered much less difficult.

Bull Rock sirens are rotated by means of a 4-cylinder pneumatic motor of 1¼-in. bore by 1-in. stroke which drives all three sirens. Its air consumption is very small, being about 5 cubic feet of free air per minute. The motor drives a central shaft from which a geared-down stock pattern chain drive (1 to 1.52) is taken to each siren. The chains are each run in a horizontal plane, at three different levels, and they carry very little load.

The arrangement of the central driving shaft is shown in Fig. 7.

The sirens are ganged so that they open their ports together. this being done by means of removable wooden plugs inserted through suitable holes in the siren cases, and then through individual ports in the fixed and rotating drums.

An adjustable friction governor is fitted to the central driving shaft by which, and by a throttle valve on the driving motor, the speed of rotation of the sirens can be finely regulated.

The sirens give a smooth note of considerable power, and the range obtained is apparently always satisfactory.

Taking the interest on the capital expenditure into account, the cost of running is about equal to that of an explosive signal firing a single shot (4 ozs. tonite) every five minutes. The new siren has the better range, and it sounds every minute which is a great advantage to ships.

Some further details of the sirens are attached, but it is hoped that it will be possible to go more fully into the air conditions inside the sirens when sounding at an early date, and the results will then be communicated to the Institution.

Details of Bull Rock Sirens

1. The speed of transmission of sound in air was taken as being about 1,110-ft. per second.

2. The note was intended to be 128 vibrations per second.

3. The sirens are three in number, sounded together, axes of trumpets 120° apart in plan, with bent heads looking towards a common centre. This centre is at the virtual mouths of the trumpets, 6-in. in front of the actual mouths. Mouths are 2-ft. diameter.

The heads of trumpets are superposed, the outside ones having their centres half a wave length apart.

The wave length for 128 vibrations is 8.67-ft., pipe length 4.335-ft., for a cone complete to apex.

This length was modified to make up for the mutilation of the apex where the cone had to be cut at 5½-in. diameter and the siren attached.

A quarter a wave length at the mouth end (virtual centre) is dipped in each case 2° below horizontal. This is not to dip the sound, but to assist in keeping the rain out.

Trumpets are 2½ wave lengths in length.

Through a slight error in the drawings, the trumpets were made longer than intended, and the actual note is one of 126 vibrations per second, and the siren speed 840 revs. per minute.

The three sirens are 6-in. diameter with 9 ports.

Speed for 128 vibrations 853 33 r.p.m.		
Speed for 126 vibrations 840 r.p.m.		
Ratio of port width to pitch (Measured on 6" dia.)		0·3 approx.
Area of throat (5½" dia.)		23·76 sq. in.
Area of ports 9 × 0·625" × 1·3125"		7·38 sq. in.
Ratio of port area to throat area		0.311
Pitch of ports (on 6" diameter)		2·0944"
Width of ports		0·625"
Length of ports		1·3125"
Equivalent port area 7·38 sq. in. × 0·3 ...		2.214
Equivalent leakage area (1/100 clearance) ...		0·24
TOTAL EQUIVALENT AREA ...		2.454

NOTE:—

The equivalent port area is the actual port area × by the fraction of time the ports are open.

The equivalent leakage area is the total periphery of ports × 1/100-in. (for an old siren) × the fraction of time the ports are closed; 2.454 × 11 cu. ft. per sq. inch per sec. × 3 sirens × 4 secs. (at Bull Rock) = 323.93 cubic feet free air per minute.

The total consumption of free air per minute is:—

324 cubic feet for 3 sirens, i.e., 26.994 cu. ft. per siren per sec.

5 cubic feet driving motor (running at 1,277 r.p.m.).

1 cubic foot driving motor the code timing machine.

Total Consumption 330 cubic feet per minute.

Checking Mud Banks in Estuaries

The Use of Spartina Grass as a Stabilising Medium

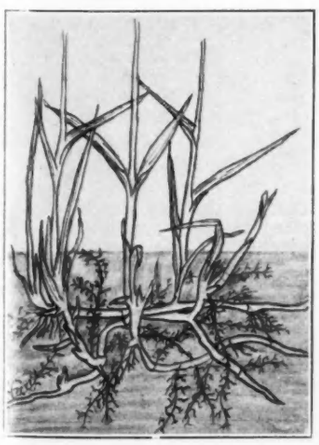
By ERIC HARDY, F.Z.S.

Unstable mud banks are a navigation trouble in most polluted river estuaries and until the creation in the wild of an entirely new maritime grass called, after a botanist *Spartina Townsendi*, it was not possible to check these banks as shifting sand dunes were checked with star-grass, for the latter will not grow in mud, and the common wigeon-grass, or *Zostera*, of the muddy estuaries is no use for holding the unstable banks. However, Spartina's growth into an expanse of matted masses of roots has proved very successful in holding the mud banks at many of our estuaries and its planting continues. Some economic aspects of this plant should, therefore, be of value to dock and harbour engineers.

The botanical causes of its origin hardly concern us here, but apparently in Southampton Water an American Spartina or cord-grass introduced with the water-ballast of whips, crossed with the native *Spartina stricta* to produce a hybrid which, by the phenomenon of doubling its chromosomes, suddenly became a fertile plant able to reproduce its own kind and thus a new species was created. R. H. Hill discovered it at Hythe in 1871, since when it has reached many estuaries, either through deliberate planting as in the Ribble above Southport, in East Anglia and Holland, or by the agency of ships, birds or currents as at Stanlow Point in the Mersey beside the Manchester Ship Canal. In all instances it has proved more virile than the native cord-grasses and it has rapidly ousted the smaller native cord-grass. On the Mersey it is nicknamed sniggle, and sometimes elsewhere it is called rice-grass.

It is easily recognised from the other two Spartinas. The small native *Spartina stricta* grows to a length of 2-ft., its leaves are jointed to their sheaths, broadest below the middle, and break easily at the joint. The American *Spartina alternifolia* which occurs on the south coast and the Franco-Spanish frontier, is not jointed, and has long, tapering, erect leaves overtopping the flower spikes. It is 3-ft. at its maximum growth. *Spartina Townsendi*, however, exceeds these by attaining 4-ft., it is jointed like the native one, but it does not break at the joints, it has prominent auricles, leaves that stand out and are broadest at the base and downy glumes or flower-heads whereas those of the native " stricta " are just hairy.

The name Spartina means cord, from the strength of its roots, and in appearance it much resembles *Leersia oryzoides*, a rare grass of wet meadows and watery places in Surrey, Sussex and Hampshire. *Spartina Townsendi*, however, is essentially a plant of the muddy saltings, and it now inhabits practically every harbour and estuary on the South Coast, especially Poole Harbour. It has also found its way to French ports like Brest. It rapidly colonises the soft, sticky tidal mud where no other vegetation grows, and its range is from high water level down to a depth of about 6-ft., but it thrives best between 2-ft. and 4-ft., tolerating from two to three hours immersion by the sea. The lowest record is in 10-ft. of water, but in deeper water its rate of growth is slower and stems under 2-ft. with 5 hours of immersion rarely flower. On soft mud it grows from 1 to 2-ft. radius per year, on firm mud it grows 6-in. radius in a year.



"Spartina Townsendi." How intertwined network of fibrous roots and creeping rhizomes of colony hold mud.

The best types for planting in unfavourable situations are two-year-old seedlings or cuttings; one-year-old seedlings are the least successful. In normal times the cost of such seedlings is about 30s. to 40s. per 1,000. In good situations they may be planted at any time. Root formation is rapid and erosion of mud banks is fairly quickly checked, but there is the subsequent danger as occurred on the Mersey at Stanlow Bank of the cord-grass increasing beyond control. Creeping rhizomes or horizontal root stocks spread just below the surface of the mud, producing surface roots for nutrition and deep anchorage roots which go to a great depth down the mud. In favourable conditions a single plant will grow to 3-ft. in diameter in 18 months and to 12 or 15-ft. in diameter in three years. In 15 to 20 years a few scattered hummocks become a continuous meadow over the mud bank. Poole Harbour had an enormous meadow of it grow from a few natural arrivals at Holes Bay in 18 years from 1906 to 1924, while at the mouth of the Vire in Normandy, a few scattered tufts in 1906 spread to a block of cord grass 4 miles square in 17 years.

Planting "Spartina Townsendi" or cord grass on the Essex mudflats.

The immediate result of colonising a mud bank with *Spartina Townsendi* is the raising of the level of the bank, as much as 8-in. in a year. This holds the mobile mud and other drift of the tidal currents, the occupied mud is firmly bound by the rising vegetation and eventually a man can walk where formerly only treacherous mud would have suffocated him. As a speedy agent for reclaiming tidal muds its economic value is immense, as it has proved in Holland where stock are later fed upon it, likewise in Poole Harbour the grass may also be cut as hay for farm stock.

The Dutch planted their seedlings 3 metres apart each way. At Hadleigh in Essex in 1929 it took 8,000 plants to plant 14 acres. But in some cases, as the Mersey Dock Board areas at Stanlow and Hightown it has been dug up again for fear of getting out of control as it did in Poole Harbour. It was tried in pure sand on the Connah's Quay side of the Dee Estuary in 1928, when 1,000 plants from Poole Harbour were put in during the early spring. About half the plants grew and seeded, stabilising the sand strip so that silt was collected, other littoral plants took root. Further plantations were made and these attained 18-in. height when they seeded; but the cord grass has not spread much, in fact it has tended to die out.

In spring the dead haulms break off the grass and are washed ashore by the high tides, but this does not seem to cause as much trouble as its spread out of control. In the latter instances, as on the Ship Canal bank beside Stanlow Point, excess growth can be checked by burning the grass in summer or poisoning the muddy growing medium, *Spartina Townsendi* can therefore be assumed to have both engineering and agricultural value as a newcomer to the British flora. Its value is the prevention of erosion, the checking of erratic river estuaries, unstable mud and possibly sand banks in the way of tidal currents so that their positions are fixed and navigation channels become permanent without frequent changes of marking buoys as occurs in some of the Mersey channels. There is a danger in time of practically all the coastal mud in temperate regions being colonised by this rapidly-spreading plant.

Wagon-loading Delays at the Quayside.

There are complaints that the utmost possible celerity is not yet being practised in the loading and release of railway stock at the ports of this country. It is represented in traffic circles that much good would result from localised efforts to hasten the loading and unloading of wagons by the more practical arrangement of work, by the adoption of labour-saving appliances and by beginning the process of loading and unloading immediately the wagons are available.

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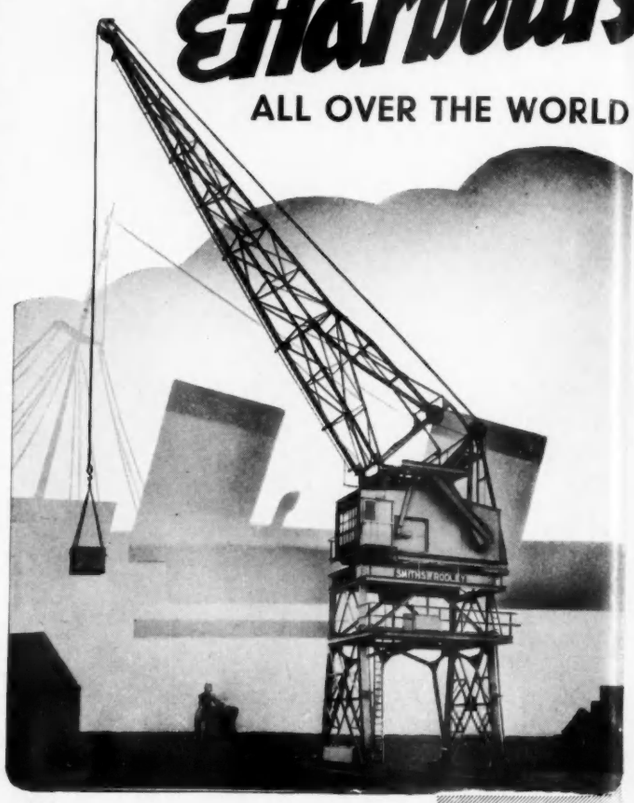

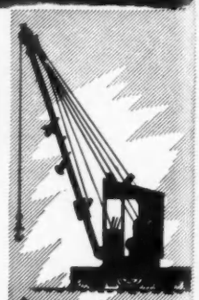

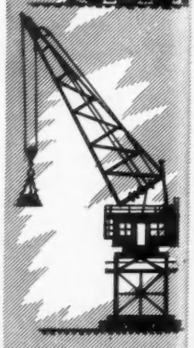

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